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MEMOIRS

READ BEFORE THE BOSTON SOCIETY OF NATURAL HISTORY.

I. On Distomum crassicolle Rud.: with Brief Notes on Huxley's proposed Classification of Worms.

By Charles Sedgwick Minot.

Read Feb. 21, 1877.

I HAVE recently[1] attempted to prove in detail that the Nemertines cannot be retained among the Plathelminths, and that the remaining forms of the class must be grouped differently from the hitherto accepted manner. One of the principal changes was the union of the Trematods and Cestods in one division under the name of the Vaginiferæ. The following paper has been prepared with a view to justify the proposed change, by a comparative investigation of a fluke and a tape worm. I have chosen *Distomum crassicolle* on the one hand, and *Caryophyllæus* on the other, as representative species. I have already prepared sections of the latter, but am obliged for personal reasons to postpone the detailed investigation of them; and it appears to me desirable, therefore, to publish my observations on Distomum at once.

I prepared in July, 1876, while in Leipzig, three series of sections, and mounted two specimens in Canada balsam. All of these preparations were stained with carmine. Each of the three series comprised a whole individual from beginning to end, and without a break; the sections were made with the aid of a sledge microtome.[2] Two of the series were of transverse, one of longitudinal sections; nevertheless there were parts of the animal which could not be well seen in any of the preparations. I must therefore apologize for the incompleteness of the following description, although unavoidable, because I cannot at present obtain any more specimens of this species.

Distomum crassicolle measures about 4 mm. in length, and 1.2 mm. in width, and its dorso-ventral diameter is about 1 – 0.9 mm. Its oral sucker is small, fig. 1, *M*, although somewhat larger than the ventral one, *S*, which is placed on the ventral median line, near

[1] Minot. On the Classification of some of the lower Worms. Proc. Boston Soc. Nat. Hist., Vol. XIX, p. 17.

Minot. Zur Anatomie der Turbellarien, zugleich ein Beitrag zur Classification der Platthelminthen. Semper's Arbeiten des Zoot.-zool. Inst. Würzburg. Bd. III, p. 405. 1877.

[2] A description of this invaluable instrument may be found in the American Naturalist for April, 1877.

the end of the anterior third of the body. The posterior two-thirds are taken up mainly by the convolutions of the uterus, *Ut.*, which in all the specimens I have examined was filled with an enormous number of eggs. The yolk glands of authors, or the egg-food-stocks, *F*, as they may be more appropriately named, lie on each side of the body, forming two masses, which when seen from above have a triangular outline. They are restricted to the first third of the body. The mouth occupies the middle of the front sucker, *M.* The digestive canal begins with a very short tube, above which lies the central nervous system, *N*, and which leads to the muscular pharynx, *Ph.* The canal continues beyond this, simple and of small diameter, until it gets about half way to the ventral sucker, where it divides, sending a simple sac-like branch, *D*, obliquely backwards and outwards on each side. These branches do not extend beyond the level of the front edge of the ventral sucker and end blindly. The digestive tract is therefore remarkably small and simple in proportion to the size of the animal. The ovary, *Ov.*, is a rounded body lying asymmetrically upon the right hand of the ventral sucker, in front of which there is a small depression, the sexual antrum, (*Geschlechtsvorraum*), in the right of which the sheath of the penis, *Pe.*, opens, while the uterus, *Ut.*, opens on the left. The penis runs backward over the sucker, and behind the point where it is attached to its sheath, it enlarges to form the penis bulb, which corresponds to the *Cirrhusbeutel* of the Cestods.[1] The testes, two in number, are of unequal size and asymmetrically placed. That on the left, *Te.*, is the smaller, and lies the further forward, being quite near the ventral sucker, while the slightly larger right-hand testis, *Te.'*, is placed further back. They are both nearly spherical. The spermiduct, *Sp. d.*, from each is very fine, and runs towards the penis bulb, into which it undoubtedly opens, though I have not been able to discover the exact communication. The uterus, *Ut.*, extends backward from its external opening, and, passing beyond the penis-bulb, then enlarges and forms the unusually complicated convolutions which, as before mentioned, fill up the posterior two-thirds of the body, and which I found it impossible to follow. It ends, however, in the shell gland (*Schalendrüse*), which lies just behind the penis, but is not represented in fig. 1. The oviduct and the ducts of the egg-foodstocks also communicate with the shell gland, from which a fine tube also runs upwards to open on the back. The main stem, *W.v.*, of the water vascular system extends from the hind end of the animal straight forward half the length of the body. Its diameter gradually diminishes as it runs forwards. It is hoped that this brief account of the general topography of the organs will serve to characterize the species, and render the following details intelligible.

In all my sections I find the outside limit of the body to be a membrane, fig. 9, *B.M.*, of nearly even thickness, but without any distinct structure, unless a faint striation indicating a fibrillar composition be regarded as such. It is armed with a number of very minute spines, which lie close together and are restricted to the anterior part of the back. This membrane is the cuticula of authors. I cannot accept that designation, because I consider it to represent a basement membrane. I have in my two previous papers already suggested this homology. I have accordingly attempted to find epidermal cells lying exteriorly to the membrane in question, but hitherto without success. I must, however, still maintain

[1] Leuckart. Die menschlichen Parasiten. Bd. I, p. 178–179.

my opinion for the following reasons: first, because I find that the supposed cuticula bends in at the mouth (*cf.* fig. 10), and continues down the digestive tube into the two branches of the same, where it becomes the basement membrane of the epithelial lining of the gut — the "*cuticula*" is therefore the continuation of an undoubted basement membrane; secondly, because our membrane corresponds exactly in appearance and position with that which is really a basement membrane in Cestods,[1] but which had always been called "*cuticula*"; it overlies a layer of glandular cells and muscles,[2] as in Caryophyllæus, Tænia and Amphilina,[3] termed by German investigators, the *Hautschicht*, and wrongly regarded as the epidermis, as I have elsewhere shown,— simply because the limiting membrane was necessarily the cuticula, and the underlying cells consequently are epidermis. In *Distomum crassicolle* and in other Trematods, there are muscular fibres close to the "cuticula," separating it from the underlying cells, which quite agrees with the interpretation of it as a basement membrane. If the view here advocated is true, we must account in some manner for there being no epithelium discoverable outside our membrane. This may be done in two ways: 1, the cells may have been destroyed in preparing the objects in the preserving and hardening fluids; or, 2, it may be a regular phenomenon of the development of Trematods that the epidermis is thrown off. On the whole, I incline to the latter view, because it would explain why no epidermis has ever been noticed upon any of the thousands of living or freshly killed specimens that have been carefully observed by helminthologists. There are, too, many cases known in which the larvæ of Distoma are provided with a ciliated external layer of cells, which is thrown off, or shrivels up, as development proceeds; I may refer to Wagener, Pagenstecher, Leuckart, v. Linstow, Zeller, and many others, as having observed this phenomenon. This justifies the supposition that the same thing may occur in adult forms. If this should turn out to be the case, the difficulties which now prevent any comparison of the epidermis of Trematods with that of the remaining Plathelminths, would be entirely removed. Until further investigations shall have determined this point, the question of the homology of the limiting layers of the body of Distomum, etc., must remain an open one.

The muscular system is not highly developed. There is but one distinct layer, formed by a single row of longitudinal fibres (fig. 9, *L*) exactly as I have found in *Caryophyllæus mutabilis* and *Tænia sp.?* from the intestine of a mocassin snake, *Cenchris piscivorus*, which had lived some time in Berlin and Würzburg. Leuckart[4] says that the Trematods have three layers of muscles, the external being a circular coat; but in *D. hepaticum* there is also a single row of longitudinal fibres immediately under the so-called cuticula. In our species there are a very few circular muscles (fig. 9, *R*) within the longitudinal layer. The dorso-ventral, or the sagittal muscles, are quite numerous, and form the most conspicuous part of the muscular system. They run for the most part nearly straight up and down, more rarely quite obliquely, but they show a great reduction in their number and complexity of arrangement, as compared with the non-parasitic Pharyngocœla, approach-

[1] Schiefferdecker was the first to describe the true epidermis of Cestods. Jena. Zeitschr. Nat. Wiss. Bd. VIII, p. 459.

[2] *Cf.* Schneider. Untersuchungen über Platthelminthen p. 5, where he especially mentions this point.

[3] W. Salensky. Ueber Amphilina. Zeitchr. Wiss. Zool., XXIV. (1874.) p. 300.

[4] Leuckart. Parasiten I, p. 459.

ing the Cestods in this respect, though in the Trematods I have examined I found no deep muscular coat which so characteristically separates the "Mittelschicht" from the "Rindenschicht" (*cf.* Leuckart, Parasiten) in segmented tape worms.

From these observations, it will be seen that the muscular system of Distomum resembles that of the Cestods more closely than it does that of the Planarians. But the existence of the single row of external longitudinal muscular fibres should be especially noted as bearing upon the homologies of the muscular layers of Plathelminths. This subject has been discussed in my paper (see above) in Semper's Arbeiten. It also overthrows, beyond all question, Schneider's[1] attempt to classify worms according to their muscular systems, because some species of Tænia do, and others do not, have the external longitudinal layer, and it is evident that orders and classes cannot be founded upon characters that are not constant within the limits of one genus.[2]

The parynchym in my preparations appears as a meshwork of granular protoplasm, with a few oval nuclei imbedded in it. The cavities of the meshwork are more or less rounded in outline. This appearance is well known, but has been variously interpreted. Walter[3] believed that there was a series of intercommunicating cavities, formed by a reticulated connective tissue; the cells of which consisted of a central area of protoplasm enclosing the nucleus and sending out processes which united with those of the neighboring cells, very much as in the embryonic connective tissue of Vertebrates. Leuckart,[4] on the other hand, asserts that the whole consists of cells, there being no real cavities; that appearance being produced by the cells containing a large amount of clear fluid, while the granular protoplasm is collected together with the nucleus against the membrane at one pole of the cell, similarly to the characteristic cells of the *Chorda dorsalis* of Vertebrates. If Leuckart's view is correct, good preparations must show a curved outline passing near the nucleus, and there must be also as many nuclei as there are distinct rounded cavities, since each of these is a cell. I have been unable to observe such an appearance, but, on the contrary, I have often seen such stellate cells as were described by Walter. In Caryophyllaeus, we find that the meshwork is very fine, the spaces being much more numerous than the nuclei, though of about the same size; if, therefore, Leuckart's view is correct, it would be necessary to explain this discrepancy between the number of the nuclei and of the spaces he calls cells; at present I do not see how this is possible. In the segmented Cestods the parenchym contains numerous pale, oval cells, without any processes, besides a few stellate cells. I am not certain of there being any corresponding cells of rounded shape in the basal tissue of the flukes. Both kinds are found in the Pharyngocœla, as I have stated in my paper in Semper's Arbeiten, and they will probably be detected in the Trematods, when properly searched for, thus adding a new minute homology within the class of the Plathelminths. I may add that Salensky[5] agrees in his description

[1] Anton Schneider. Untersuchungen über Platthelminthen. Giessen. 1873.

[2] Huxley, in his recently published Manual of the Anatomy of Invertebrates (Amer. ed., p. 172), repeats the current statement that the circular coat is external. Of course this statement requires modification to accord with recent observations.

[3] Walter. Beiträge zur Anatomie einzelner Trematoden. Archiv f. Naturgesch., 1858. Theil I, p. 287.

[4] Leuckart. Menschl. Parasiten. Bd. I, p. 457–458.

[5] Salensky. Amphilina. Zeitschr. wiss. Zool., XXIV, p. 303.

of the parenchym of Amphilina with what Walter and myself have found in other Trematods. Blumberg[1] agrees with Leuckart, while Schneider[2] gives a singular interpretation to the histological appearance of the parenchym, which seems to me quite unwarrantable.

The curious cords of fine trabeculae, forming a meshwork, and to which the Germans have applied the name of *Balkenstränge*, are known to exist in a variety of Planarians and Cestods, and Salensky describes them in Amphilina, but I cannot discover anything like them in *Distomum crassicolle* nor *D. hepaticum*.

The true water vascular system (fig. 1, *W.v.*) may, however, be very easily seen; in part, at least. There is only one main stem, which is enormously large. It begins at the hind end of the animal, where it opens externally, and enlarging very quickly (fig. 7) it runs straight forward (fig. 1, *W.v.*) close underneath the back, its diameter gradually diminishing, reaching half the length of the body. I have not seen any branches or canals connected with it. One might perhaps easily discover them with the help of injections, which I hope to try at some future time. In my series of longitudinal sections, there are several in which the wall of vascular sac is cut parallel to its surface. In these cases there are a number of pale nuclei visible. They are themselves of unequal size (fig. 8), but are much larger than any other nuclei in the body of the worm. They are at irregular distances from one another, and though they probably form part of a pavement epithelium, yet I could not trace any indication of intercellular lines, or of cell membranes around them. But the characteristic feature in the lining of the main sac is the presence of innumerable small, highly refractile granules, nearly spherical in shape, and yellowish in color (fig. 8). They are of various sizes, irregularly distributed, but apparently never touching one another. I can surmise nothing as to their nature. They appear with equal distinctness in transverse sections, and lie within the membrane upon which the *Intima* rests. This may be considered a basement membrane; it has a fibrous structure and is colored by carmine.

I agree with Walter (*l. c.*) in considering the spaces in the parenchym to be connected with the water vascular system. In *Distomum hepaticum* I have seen branches pass off from the main stem and connect directly with the lacunae of the parenchym, but my attempts to repeat this observation on *D. crassicolle* have hitherto been unsuccessful.

Among the dermal muscles, and immediately underneath the so-called "*cuticula*," are pear-shaped cells, with large circular or oval nuclei, which are usually not uniformly stained, and contain distinct nucleoli. These are probably unicellular glands, at all events they are, as is proven by their position and histological character, the homologues of the layer of gland cells which underlies the basement membrane in Cestods and Pharyngocoela. I have seen them in various Trematods, and they probably exist in all flat worms. But in Trematods and Cestods they are less developed than in the Planarians, showing the close relationship of the two parasitic orders.

The oral sucker may be best described in connection with the digestive apparatus. The ventral sucker (fig. 7, *S*) is a small circular disc, whose vertical diameter is about one-third of the width of the disc (fig. 11, *S*, longitudinal section). It is composed mainly of ver-

[1] Blumberg. Ueber den Bau des Amphistoma conicum. Inaug. Diss. Dorpat, 1871.

[2] Schneider. Untersuchungen über Plathelminthen. 1873. p. 12–15.

tical muscular fibres. The basement membrane of the body passes over its free surface, and there is another basement membrane separating the sucker interiorly from the parenchym (see fig. 11, *b.m*). The upper and the lower surfaces of the sucker are nearly parallel with each other, therefore the vertical muscular fibres are almost of uniform length. They run somewhat irregularly, and seem often to bend around at their ends, as may be observed in the sucker of Mesodiscus,[1] Tænia,[2] etc. There are only very few circular fibres, and I have not noticed any radiating ones. The suckers of all Plathelminths that I have examined are characterized by the great predominance of the vertical fibres, differing in this respect from those of the leeches, which are formed chiefly by circular and radiating fibres.[3] Between the fibres in *D. crassicolle* there are numerous rather large oval nuclei, with a very darkly stained nucleolus, which is highly refringent and excentrically placed. To what sort of cells these nuclei belong I cannot make out. They are mostly congregated in the upper part of the sucker.

The oral sucker (fig. 10, *M*), as seen in longitudinal section, presents the same histological appearance as the ventral sucker. The digestive canal passes through it a little below its middle, and descending obliquely forwards it reaches the mouth. The vertical fibres are here placed perpendicularly to the axis of the digestive tube. In life, however, the sucker can be everted, so that what forms the beginning of the intestinal canal when at rest, is spread out so as to form the flat outer surface of the sucker. Under these circumstances the arrangement of the fibres corresponds precisely to that found in the ventral sucker; we may therefore conclude that the primitive form is that preserved in the ventral disc, while the oral sucker has undergone a secondary alteration producing its present shape.

Immediately behind the sucker of the mouth there follows a short division of the intestine before we reach the pharynx (fig. 10, *a*). The shape of this part depends upon the position of the pharynx; when that organ is drawn back the division in question is drawn out to a narrow straight tube; when the pharynx is pulled forward the tube is shortened, and bulges out, as drawn in fig. 10. This præpharynx exists probably in all Trematods, its use being to permit the free play of the pharynx backward and forward.

The pharynx (fig. 10, *ph.*) closely resembles the oral sucker in its minute anatomy, but is very much smaller, and the oval nuclei are most numerous among the posterior fibres. Up to this point the axis of the digestive canal has been straight.

Just behind the pharynx (*cf.* fig. 10) it bends suddenly upwards, and ascends to the dorsal side of the body, and then curves backward and runs without again changing its direction or character, directly to the point where the fork of the intestine branches (*cf.* fig. 7). This part may be called the œsophagus. It is provided with an internal circular muscular coat, and an external longitudinal one, as may be easily seen either in longitudinal (figs. 10 and 12) or transverse sections. Each coat is composed of a single layer of delicate fibres.

Up to where the intestine branches, I have found it lined by the inflected continuation of the basement membrane of the body, but without any epithelium; which probably exists,

[1] Minot. Semper's Arbeiten. Bd. III, Taf. XVIII, Fig. 36. Zeitschr. f. Wiss. Zool., 1873. Taf. IX, Fig. 2, *D.*
[2] Nitsche, H. Untersuchungen uber den Bau der Taenien [3] Leuckart. Parasiten. Bd. I, p. 646.

though as far as I am aware, there is no special statement published concerning an epithelial lining of the œsophageal and pharyngeal regions in Trematods. I have again and again had occasion to observe the destruction of the intestinal epithelium in various worms by the action of alcohol and other hardening fluids, and for the present I must therefore assume that the same cause explains the absence of the epithelium in the specimens I have examined.

The two cœcal branches (figs. 1 and 3, *D*) are lined by a very distinct and beautiful epithelium (fig. 12, *A*, transverse section of the wall of the cœcum), consisting of short, broad, cylindrical cells, containing each a proportionately large oval nucleus. The nuclei lie in the middle or basal portion of the cells, never in the upper part, and have sometimes one, more frequently two, highly refractile, eccentric nucleoli. The protoplasm of the cells is granular, the upper part is more deeply stained by carmine than the lower. In some of my preparations this epithelium is cut parallel to its surface; fig. 12, *B*, represents such a spot. The amount of intercellular substance is small, and the cells present polygonal outlines, and are four, five, or six-sided. The epithelium, as is shown in fig. 12, *A*, rests upon a basement membrane. The muscular layers outside are reduced to a few fibres running in various directions, but apparently mostly circular. A similar epithelium to the one here described I have found in several other Trematods, so that it may be considered characteristic of the class. It is very different from the intestinal epithelium in Planarians, and as far as I know, from that in any other class of worms.

There are a great many unicellular glands in the anterior part of the body. They are bottle-shaped (fig. 14), their necks running out towards the oval sucker. Their contents appear collected, as seen in the figure, almost exclusively on one side, forming there a very dark stained, finely granulated mass enclosing a relatively small nucleus, which can only be detected by close examination. The other half of the cells is quite clear and colorless. Is it not probable that this peculiar distribution of the granular matter is caused by the alcohol producing a contraction of the cell-contents? The body of the cells is very large, and rounded at one end, while it tapers gradually towards the other, till it runs over into a long narrow tube, which may be called the duct. The cell membrane is very distinct. The cells are distributed further back on the ventral, than on the dorsal side. Transverse sections show the nuclei much more distinctly than longitudinal ones do. In a section through the hind end of the oral sucker (fig. 2), the ducts of the ventrally placed cells may be seen at each side, while the bodies of cells situated dorsally are seen crowded together in the upper part of the section. These glands are undoubted homologous with the so-called "Speichel-drüsen" of German authors, first mentioned by Walter.[1] and since then observed by various other writers.[2] Similar glands are said to exist in various Pharyngocœla, but I have not observed them in any of the Planarians I have investigated.

The great development of the uterus, and the large number of eggs contained in it, effectually hide some parts of the sexual apparatus, my description of which will therefore be somewhat incomplete.

[1] Walter. Zeitschr. Wiss. Zool. Bd. VIII, p. 198-199; and Archiv für Naturgesch. 24 Jahrg. Bd. I, (1858) p. 291–292.

[2] Leuckart. Parasiten, I, p, 470.

The testes are of unequal size and asymmetrically placed (fig. 5), as I have already mentioned. They are surrounded by a fibrous membrane just like that which encloses each sexual gland in the Planarians,[1] and forming a complete envelope. This membrane is continued on to the efferent duct (fig. 13, *d*, *e*), which is a small tube. Neither within this tube nor within the testicular capsule, have I been able to discover any traces of a lining epithelium. The contents of the testicles are cells, and spermatozoa both ripe and in various stages of development, but all irregularly distributed, producing such confusion that the exact development of the spermatozoa cannot be followed. I could only make out that the heads are developed out of the nuclei of the parent cells.

The efferent ducts run towards the penis bulb, into which they of course open, though I have not seen the communication. The penis bulb is really the fixed basal portion of the penis. Its walls, as seen in transverse section, fig. 4, *A*, are very thick, and marked off both internally and externally by a thin membrane, whose appearance recalls the basement membrane of the body. The rest of the wall between the limiting layers consists mainly of rounded cells each containing a nucleus, but with their remaining histological characters nearly obliterated in all my preparations. The cavity of the bulb contains a mass which I suppose to be the coagulated sperm, but no evidences of an epithelial lining are visible, nor can any distinct muscular fibres in the wall of the bulb be seen, though usually they are highly developed in Plathelminths.

The general shape of the penis and its bulb may be best seen in fig. 11, which represents a longitudinal section. The penis proper is seen to rise almost perpendicularly at first, and then curving around backwards to gradually enlarge, passing over into the bulb without any sharp line of demarcation. I could not make out the distribution of the muscles in the penis on account of the numerous cells, apparently glandular, whose large, dark stained nuclei are very noticeable. The canal is not straight, but undulatory in its course. I am quite sure there is no flagellum. The penis bulb is the same organ that Moseley[2] calls the *Prostata* in Planarians, and corresponds to the *Cirrhusbeutel* of the Cestods. I have in my previous papers already noticed the exact homologies which may be traced in the male organs of Plathelminths, and in *D. crassicolle* we find the same parts: 1. testicles, 2. spermiducts, 3. penis bulb, 4. penis, 5, penis sheath, or male antrum. The slight development of the penis bulb, with its few muscles, in Trematods, is like what we find in the Cestods,[3] but very unlike the enormous muscular sack of Planarians, again testifying to the close relationship existing between the two parasitic orders.

The ovary (fig. 4, *Ov.*) is asymmetrically placed, and presents in transverse section a nearly circular outline, its diameter being about the same as that of the larger testicle, namely, two-thirds of the vertical diameter of the body. Like the testicles, it is surrounded by a delicate membranous envelope, closely connected with the parenchym. The ovary consists of numerous rounded cells, with a distinct membrane and large oval nuclei; part of the body of each cell is clear, the remainder is filled with a dark stained, finely

[1] Minot. Semper's Arbeit. Bd. III, Hft. IV.

[2] Moseley. On Stylochus, etc. Quart. Journ. Micros. Sci. Jan., 1877.

[3] *Cf.* Leuckart. Parasiten, I, pp. 178, 263; and Sommer und Landois. Bau der geschlechtsreifen Glieder von Botriocephalus latus. Zeitschr. wiss. Zool., XXII. (1872.) pp. 54, 77.

granulated protoplasm. Nearly all the cells are developed to about the same extent, but whether or not they are arranged in the form of a branching tubular gland, as in the Cestods,[1] I have not been able to determine. The oviduct is larger than the efferent canal of the spermaries, and opens into the shell gland on the underside.

Fig. 6 is a diagrammatic combination of several sections, made from camera lucida drawings of each section, which were traced on thin paper, and then superposed. The drawing corresponds, therefore, to several successive planes. The ovary, *Or.*, lies furthest forward, and gives off the oviduct *Ovd.*, which is a tube of considerable size; but the connection of which with the shell gland is not represented in the figure. The shell gland, *Sh.g.*, is the enlarged end of the uterus; its upper extremity is constricted, and opens into a large spherical vesicle, the spermatotheca, *Sp.th.*, which I have found filled with spermatozoa in all my specimens. In the individual whose female organs are represented in fig. 6, the whole of the beginning of the uterus was filled with sexual products, so that the course of the tube was comparatively easy to follow. It descends downward on the left, then bends abruptly upwards for a short distance, then downwards again, making a U-shaped curve to the right. In this portion the eggs are already surrounded by a membrane, which increases in thickness as the eggs pass down the uterus. In the shell gland, *Sh.g.*, spermatozoa, food cells (*yolk cells* auct.) and egg cells proper, are all intermixed. Passing down the uterus we no longer distinguish any spermatozoa, but the food cells gradually become balled together around the egg cells, and the pellets, as we might call them, thus formed, appear at the beginning of the U-shaped bend, above mentioned, surrounded by a thin membrane or shell.

There is also shown in fig. 6, *Vg.*, a delicate tube running from the upper or constricted end of the shell gland upwards to the middle of the back. This is the vagina. Its course is incorrectly represented in the drawing, inasmuch as it is really much more irregular than I have figured it, so that great pains were necessary to follow it in my sections, but I finally succeeded in tracing it from the back to the shell gland. I paid particular attention to this point, because it was on account of the existence of a vagina in both orders that the union of the Trematods and Cestods was first proposed. The vagina was first discovered by Blumberg[2] in *Amphistomum conicum*, and his observations led Stieda[3] to suppose that Laurer's[4] canal, which was long held to connect the testicles with the shell glands, and had been found in thirteen different species of Trematods (*cf.* Stieda l. c.), was really a vagina, since Blumberg found it to be so in Amphistoma, and Stieda in *Distomum hepaticum*. Zeller[5] has since described a vagina in *Distomum macrostomum*, and found two vaginæ in *Polystomum integerrimum*.[6] Independently, and ignorant of these discoveries, Dr. Fitz, in his excellent paper on the anatomy of *Fasciola Jacksoni*,[7] found the vagina in that

[1] Sommer u. Landois. Ueber Bothriocephalus. loc. cit., XXII, p. 57–58. Sommer. Uber Tænia, etc., loc. cit., XXIV, p. 528 und Taf. XLIII, *m*.

[2] Blumberg. Ueber Amphistomum conicum. Inaug. Diss. Dorpat, 1871.

[3] Stieda. Ueber den angeblichen inneren Zusammenhang der männlichen und weiblichen Organe bei den Trematoden. Archiv für Anat. Phys. Wiss. Med., 1871, p. 31.

[4] Laurer. Disquisitiones anatomicae de Amphistomo conico. Diss. inaug. Gryphiae. 1830.

[5] Zeller. Ueber Leucochloridium paradoxum. Zeitschr. wiss. Zool., XXIV. p. 569.

[6] Zeller. Weiterer Beitrag zur Kenntniss der Polystomen. Zeitschr. wiss. Zool., XXVII, p. 249.

[7] Fitz. New York Med. Journ. Nov., 1876.

species also. These observations seem to me sufficient to justify the conclusion that this canal exists in all Trematods, while it is evidently the same as the vagina in Cestods. No corresponding tube has yet been observed in any of the Pharyngocœla.

All the female organs thus far described are lined by a delicate membrane, which is lightly colored by carmine; it appears structureless, and I have not noticed any epithelium or muscular coats connected with it.

I have to add that the uterus does not always begin with just such curves as are represented in Fig. 6, *Ut.* Upon leaving this part of the body it runs backward, enlarges, and after a very long and irregular course it passes forward, diminishes its diameter, and curves downward on the left of the penis, beside which it finally opens. Around its terminal portion there are numerous cells, probably glandular, having large nuclei, very much like those seen in the penis.

The shell gland and the beginning of the uterus are surrounded by numerous pear-shaped cells, containing a nucleus in the rounded end, while the narrow neck, which is supposed to act as a duct, is directed towards the uterus. These cells have been found in a great many Trematods and Cestods, and are supposed to secrete the matter that forms the egg shells; if this be the case, they will probably be found in some form in Planarians, etc. They are so much alike in Trematods and Cestods that they afford an additional argument for the union of the two orders.

The egg food stocks, as may be seen for example in fig. 4, do not form two solid glands, but are broken up into a number of more or less spherical divisions (fig. 16), from which run out short ducts; all those of one side finally collect together in one common duct, which runs obliquely backward, meeting its fellow from the other side directly over the shell gland. I cannot say in what manner they finally open into the shell gland. They can be seen in fig. 1 as two dark lines, one crossing the ovary, the other passing just in front of the left testicle.

All the cells in the food-stocks appear to be fully developed, and I find none still undergoing change into food cells; this agrees with the large number of eggs in the uterus indicating that all my specimens had been sexually mature for some time. The food-cells, fig. 16, are large and spherical, with a pale nucleus placed centrally, but nearly concealed by the great number of large refringent granules in the protoplasm, giving the yolk cells their brownish coloring. The cells seem to be more or less distinctly separated from one another, each having a special membrane, but with no visible intercellular cement. This structure of the food-cells is common to all Vaginifers, at the time the cells are ready to break loose and pass to the shell gland.

The eggs in the upper part of the uterus are elongate spheroids in fig. 15, *A*, and the food-cells already reduced in size, can still be distinctly seen. Further down the uterus the eggs gradually become concavo-convex, as appears most distinctly in optical section, fig. 15, *B*, the shell growing much thicker and more resistant. Freshly laid eggs still present the same appearance.

The central nervous system appears as a transverse fibrous band overlying the hind end of the oral sucker (fig. 2), and enlarged at each side where the ganglionic cells mostly lie. They are indistinct in all my preparations. I could not follow any nerves from the band. In position and appearance it is exactly like the central nervous system in other Trematods.

In two papers, cited at the head of this article, I have already considered the striking similarity existing between the flukes and the tape worms in their adult forms. The examination of *Distomum crassicolle* has confirmed my views; but it is not yet possible to perfectly homologize the water-vascular system in the two orders, nor to explain the absence of the nervous system and the digestive canal in the Cestods. In all other respects there is an essential agreement; but the developmental history, accompanied in one order by a different alternation of generations from that occuring in the other, must be explained before the union of the two divisions can be settled beyond all possibility of doubt.

Prof. Huxley[1] has recently proposed some alterations in zoological classification, apparently taking Hæckel's gastræa theory as a starting point. He is thereby led to suggest various changes in the classification of the worms, which result in an arrangement very different from that which seems to me most near the truth.

I cannot but consider it very unfortunate that Prof. Huxley has so entirely accepted the gastræa theory, for it has been very severely condemned by various competent naturalists, and it is not, so far as I am aware, generally adopted. Sufficient condemnation of the theory that the primitive germinal layers are really homologous in the ways expounded by Hæckel, is found in the fact that the layers arise by processes apparently altogether different in different animals; for it is the established law that those parts are the same which are formed in the same manner. That the germinal layers are homologous, few naturalists now doubt; but that the Gastrula is the primitive form has been as urgently denied by some embryologists as affirmed by others. Under these circumstances it seems to me premature to recast the whole of zoological classification in accordance with the demands of the "*Gastræatheorie*."

I am not surprised, therefore, that Prof. Huxley's results are very discordant with those of other naturalists as to the classification of the worms. Huxley, taking into consideration that the adult tape worms have no digestive canal, as do their allies, suggests separatting them from the other Plathelminths, and joining them with the Acanthocephala under the name of Agastræa. I believe that there is not a single close homology yet demonstrated between the Echinorhynchi and the Cestods, while, on the other hand, it has long been known that the Cestods were related to Trematoda and Turbellaria, and I have only endeavored to show that the relationship is even much closer than had been supposed. I am not aware that Huxley has brought forward any new arguments which prove the impossibility of maintaining the order of the Vaginiferæ.

Prof. Huxley has further divided the class Annelida, separating the Oligochæta from the Polychæta, upon what appear to me very insufficient grounds. What especially concerns us here is the approximation of the annelidan leeches and the Trematods; in favor of this union I am not acquainted with a single argument, and therefore it appears unnecessary to discuss it further, for I hold it for a well established truth that the leeches are annelids and have no immediate connection with the Plathelminths.

[1] Huxley. On the Classification of the Animal Kingdom. Journ. Linn. Soc., Lond., Vol. XII, p. 199.

NOTE. Since this article passed from my hands, three papers on the anatomy of Trematods have appeared. The first is by Dr. Cobbold,[1] and does not contain anything of special interest in connection with the views above advocated. Dr. Cobbold is apparently unacquainted with the discovery of the vagina, and makes no mention of any structure corresponding to Laurer's canal, which Huxley however describes,[2] in *Aspidogaster conchicola*, as running from the upper end of the oviduct (*i.e.*, the uterus) back to the testis. He adds in a note that the description is based upon observations made before the publication of Blumberg and Stieda's discoveries, and at that time he had no doubt of the connection of the canal with the testis. The third and most important article is a capital memoir by Dr. Wierzejski,[3] who describes in a Calicotyle from *Raja Schulzii*, a double vagina, so that the female apparatus has three external openings, and resembles very closely that of Polystomum as described by Zeller (*l. c.*).

EXPLANATION OF PLATE I.

The drawing on stone was made by Mr. J. H. Emerton, to whose admirable skill I am much indebted.

LETTERS COMMON TO ALL THE FIGURES.

B.m.	Basement membrane.	*Ov.*	Ovary.	*Sp.d.*	Sperminduct.
D.	Branches of the intestine.	*Ovd.*	Oviduct.	*Sp.th.*	Spermatheca.
E.	Eggs.	*Par.*	Parenchym.	*Sz.*	Spermatozoa.
F.	Food stocks.	*P.b.*	Penis bulb.	*Te.*	Left testicle.
Gl.	Salivary glands.	*Pe.*	Penis.	*Te'.*	Right testicle.
L.	Longitudinal muscles.	*Ph.*	Pharynx.	*Ut.*	End of uterus.
M	Mouth and oral sucker.	*R.*	Circular muscles.	*Ut'.*	Convolutions of Uterus.
N.	Central nervous system.	*S.*	Ventral sucker.	*Vg.*	Vagina.
Oe.	Œsophagus.	*Sh.g.*	Shell gland.	*W.v.*	Water vascular trunk.

Fig. 1. Gives a general view of the whole animal seen from below.

Figs. 2–6. Transverse sections at various heights, arranged in their natural succession from in front backward.

Fig. 2. Through the hind end of the oral sucker, to show the central nervous ganglion.

Fig. 3. Through the two branches of the digestive canal.

Fig. 4. Oblique section passing through the ovary and the blind end of the right digestive cœcum, and the front of the ventral sucker. *Cf.* Fig. 1.

Fig. 4. *A.* Transverse section of the penis bulb.

Fig. 5. Slightly oblique section through both testes.

Fig. 6. Diagrammatic combination of several sections, to show the origin of the uterus, and its relation to the shell gland and vagina.

Fig. 7. Through the hind end of the fluke, to show the main water-vascular trunk.

Fig. 8. Surface view of the lining of the water vascular system.

Fig. 9. Basement membrane of the body, with the underlying skin muscles. *Dr.*, subcutaneous glands.

Figs. 10 and 11 represent longitudinal sections.

Fig. 10. Through the mouth, pharynx and œsophagus. *a.* prepharyngeal region of the digestive tract.

Fig. 11. Through the ventral sucker and the penis.

Fig. 12. Epithelium of the digestive cœca. *A.* Transverse section. *B.* Surface view.

Fig. 13. Connection of the sperminduct and testicle.

Fig. 14. Cells of the so-called salivary glands.

Fig. 15. Eggs. *A.* from the upper, *B.* from the lower part of the uterus.

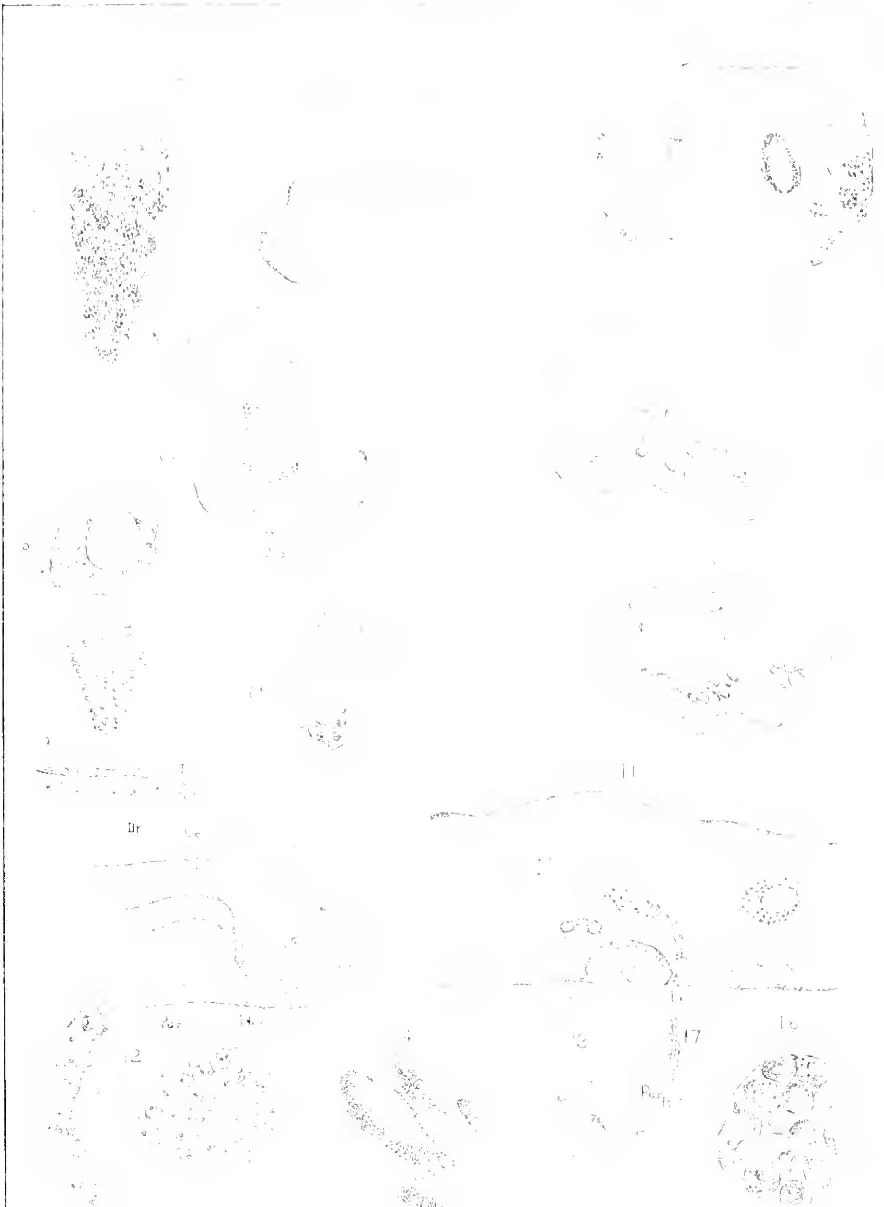
Fig. 16. Egg-food-stock.

Fig. 17. Longitudinal section of the walls of the œsophagus.

[1] Cobbold. Journ. Linn. Soc., Lond., Vol. XIII, p. 35.

[2] Huxley. Anatomy of Invertebrate Animals. Chap. IV.

[3] Wierzejski. Zur Kenntniss des Baues von *Calicotyle Kroyeri* Dies. Zeitschr. f. wiss. Zool., XXIX, p. 550.



II. The Early Types of Insects; or the Origin and Sequence of Insect Life in Palaeozoic Times.

By Samuel H. Scudder.

Read Nov. 20, 1878.

In the year 1833, Audouin exhibited at a meeting of the Entomological Society of France the wing of an orthopterous insect from Coalbrook Dale in England.[1] This was the first discovery of insects in the coal-formation. Since then many authors, notably Germar and Goldenberg,[2] have added to our knowledge of the insects of the palaeozoic rocks, until now perhaps one hundred species are known. Yet insect remains in these strata may still be looked upon as the greatest rarities. By far the larger part of these hundred species are known to us by single specimens, and very fragmentary ones at that — a wing or even a mere piece of a wing being usually all that we know of a given form. It has been claimed by some writers that we should anticipate the earliest types of insects to be winged and not apterous, and the remains that have been found would seem at first glance to sustain such a hypothesis. But as the wings retain after inhumation more characteristic features than other parts of the body, it is not surprising that naturalists have made most use of them in describing the fossil forms; and we should scarcely be warranted in deducing therefrom the absence of other fragments of the body; moreover a characteristically apterous form of

[1] Ann. Soc. Ent. France, Vol. II, Bull., p. 7–8. It is also stated that the same specimen was exhibited by Audouin on Feb. 25, 1833, before the Académie des Sciences; but no report of the meeting was published, unless in *Le Temps* newspaper, which I have not seen. The insect was considered by Audouin as neuropterous, but has recently been shown by Swinton to be orthopterous.

[2] For Germar's writings on palaeozoic insects, see the following:— 1. Beschreibung einiger neuen fossilen Insecten. < Munst., Beitr. z. Petref., V: 79–94, pl. 9, 13. 4°. Bayreuth, 1842.—2. Die Versteinerungen des Steinkohlengebirges von Wettin und Lobejün in Saalkreise. f°. Halle, 1844–53.

For those of Goldenberg, see the following:— 1. Prodrom einer Naturgeschichte der fossilen Insecten der Kohlenformation von Saarbrücken. < Sitzungsb. math.-nat. Cl. K. Akad. Wiss. Wien, IX: 38–39. 8°. Wien, 1852. (In this his name is given as Goldberger).—2. Brief an Herrn v. Carnall. < Zeitschr. Deutsch. Geol. Gesselsch., IV: 246–48. 8°. Berlin, 1852.—3. Ueber versteinerte Insectenreste in Steinkohlengebirge von Saarbrucken. < Amtl. Ber. Vers. Gesellsch. deutsch. Naturf., XXIX: 123–26. 4°. Wiesbaden, 1852.—4. Die fossilen Insecten der Kohlenformation von Saarbrucken. < Palaeontogr., IV: 17–10, pl. 3–6. f°. Cassel, 1854.—5. Beitrage zur vorweltlichen Fauna des Steinkohlengebirges zu Saarbrucken (Uebersicht der Thierreste der Kohlenformation von Saarbrucken). < Jahresb. K. Gymn. u. Vorsch. Saarbr., 1867, 1–26. 4°. Saarbrucken, 1867.—6. Zur Kenntniss der fossilen Insecten in der Steinkohlenformation. < Neues Jahrb. f. Mineral., 1869: 158–68, pl. 3. 8°. Stuttgart, 1869.—7. Zwei neue Ostracoden und eine Blattina aus der Steinkohlenformation von Saarbrucken. < Neues Jahrb. f. Mineral., 1870: 286–89 with figures in text. 8°. Stuttgart, 1870.—8. Fauna Saraepontana fossilis. Die fossilen Thiere aus der Steinkohlenformation von Saarbrucken. Heft 1–2. 4°. Saarbrucken, 1873–77. (Heft 1 is the same as No. 5, above, with the addition of plates: a supplementary part is promised by Goldenberg.)

For other papers descriptive of the palaeozoic insects of Europe, see the writings of Andree, van Beneden and Coemans, Preudhomme de Borre, Brodie, Charles Brongniart, Buckland, Corda, Curtis, Dohrn, Frič, Geinitz, Giebel, Hagen, Heer, Jordan and Meyer, Kirkby, Mahr, Murchison, Roemer, Rost, Salter, Sternberg, Swinton, and Woodward; and for those of America, papers by Dana, Dawson, Harger, Lesquereux, Meek and Worthen, Scudder, and Smith.

cockroach[1] has been described from the rocks of Saarbrücken, which are as old as any of the insect-bearing beds of Europe. The insects of the middle Devonian of New Brunswick,[2] on the other hand, are known only by their wings and the most diligent examination of thousands of fragments of shale has failed to reveal anything else. Further discussion of this point may be dismissed with the remark that geological data are not likely to throw much light upon it.

It is of course of prime importance that we should understand the relative subordination of groups in insects, before investigating their order of succession in time. Many attempts have been made to harmonize the current views of their relative rank and geological succession: but hitherto with indifferent success, mainly from the prevalence of the opinion that Coleoptera were to be ranked highest among insects, while this suborder has been known, from the first, to occur in Carboniferous strata, and some other suborders only much later. Another obstacle which has stood in the way of a clear comprehension of the facts has been the very common division of hexapod insects into two series, upon which the English entomologists have perhaps specially insisted, called Mandibulata and Haustellata, a division based upon inadequate physiological grounds. Or if it be maintained that the function expressed in these names has a structural basis, it would be easy to point out that in either of the two divisions the diversity of structure of the mouth parts is so great as to admit of no common expression in other than physiological terms. If it were not so, the claim made by Agassiz,[3] on embryological grounds, of a higher rank for the haustellate insects would hold good, and we should be at a loss to account for the simultaneous appearance of Coleoptera and Hemiptera.

An apparently more rational division of the true insects into two series is that which separates those with complete from those with incomplete metamorphosis; the young in the former case unlike, in the latter resembling, the parent. This however, taken absolutely, separates closely allied groups, such as the caddice flies and dragon flies, and one form of metamorphosis shades into the other; moreover it allies the Coleoptera with the Hymenoptera rather than with the Hemiptera or Orthoptera, and disaccords to so great a degree with the general relations of structure among insects as to show that it cannot be considered as of so fundamental an importance as we should suppose it would prove. Yet it is an important factor in the life history of insects, and cannot be disregarded totally, as is done in divisions based upon the mouth parts, but must be considered in any attempted distribution of the suborders. So too must the nature of the wings, for the possession of wings is the preëminent characteristic of hexapods as a whole, and we should naturally anticipate fundamental features in the differences of their structure.

My own view of the primary relations of the suborders of hexapods was first expressed by Packard in 1863,[4] when he said that Coleoptera, Hemiptera, Orthoptera, and Neuroptera "seem bound together by affinities such as those that unite by themselves the bees, moths and flies." To the latter or higher series he has since applied[5] the term METABOLA

[1] (*Polyzosterites granosus n. s.*) Goldenb., Faun. Sar. foss., I: 18, pl. 1, fig. 17.

[2] These Devonian insects, which were first briefly noticed by me in Bailey's Observations on the Geology of Southern New Brunswick (8°. Fredericton, 1865) will form the subject of a special paper now nearly completed.

[3] L. Agassiz. Classif. ins. embryol. data. pp. 4–8.

[4] Packard. On synthetic types in insects. Bost. Journ. Nat. Hist., VII: 591–92.

[5] Packard. Guide to the study of Insects. Introduction. 8° Salem, 1869. In later editions these names are also introduced in the text, on p. 104, with varying spelling.

(in a more restricted sense than first used by Leach), and to the former, HETEROMETABOLA. The Metabola are unquestionably more homogeneous than the other group. One of their primary features is found in the more clearly marked regional divisions of the body; this is a consideration of great significance, since in the progress of structure, from the worms, through the crustaceans to the insects; or within the class of insects, from the myriapods, through the arachnids to the hexapods; or in the developmental history of the Metabola themselves, from the larva, through the pupa to the imago, we discover a constantly increasing concentration of the segments of which the body is composed into distinct regions, culminating in the Hymenoptera, where head, thorax and abdomen are most sharply defined. This feature was first insisted upon by Agassiz in his remarkable essay on the classification of insects (l.c., pp. 20–28), but its application to the division of the hexapods has not before been pointed out; yet a very little consideration will show how much more clearly these regions are marked in the Metabola than in the Heterometabola, especially if the separation of the thorax and abdomen is examined. This is indeed what we might, not unreasonably, look for in the highest members of a group characterized, as are the hexapods, by the possession of organs of flight: the greater development of these organs would necessitate a more compact and distinctive organization of the region devoted almost exclusively to them; and accordingly in the Metabola we have, on the one hand, a more highly organized thorax, more definitely separated from head and abdomen, than in the Heterometabola; and on the other hand, greater power of continuous flight, of poise, of rapid movement, of sudden and repeated change of direction, and a far greater grace of movement in the former than in the latter.[1] This specialization of the thorax led me at one time to think of proposing the term Sternoptena for the Metabola; and, in allusion to the general preponderance of the abdomen in the groups composing it, Gastroptena for the Heterometabola. For the latter series the term Gastroptena would be more distinctive, but the names suggested by Dr. Packard seem to me better adapted to general use, besides having the advantage of prior application, and I accordingly adopt them.

In addition to the primary features mentioned (which were not stated by Packard), the Metabola are characterized by a usually cylindrical body with a very small prothorax; mouth parts formed in whole or in part for sucking, the points of the mandibles seldom opposed to each other; front wings membranous and much larger than the hind wings, which latter are sometimes aborted; the larva cylindrical and very unlike the adult, and the pupa always inactive. The Heterometabola on the other hand usually have a flattened body, with a very large prothorax; mouth parts usually adapted for biting, the points of the mandibles then opposed to each other; front wings usually more or less coriaceous or with very numerous and thickened veins, and usually smaller than the hind wings, which latter are only exceptionably aborted, and never throughout large groups; the larva is usually flattened, often resembling the adult, and the pupa either active or inactive.

[1] This we affirm only as a general rule, taking each suborder as a whole. There are, it is true, apterous or subapterous Hymenoptera, bungling and inert fliers among the Lepidoptera, and Diptera which have a heavy and direct flight; and on the other hand, groups like the Odonata among Neuroptera, whose rapidity and power of sudden change of flight is very striking;—but these do not affect the characters of suborders as wholes; and in the exceptions which might be noticed, the specialization of flight is nearly always accompanied to a certain degree by a corresponding development and distinctiveness of the thorax.

The exceptions in the former group are only in the Hymenoptera, which usually have mandibles well developed for opposing each other. In the latter, more heterogeneous group, the exceptions are more abundant. In the Coleoptera the metamorphosis is complete.[1] In the Hemiptera, the mandibles are developed as needles and with the other parts of the mouth form a sucking tube; in many of them also the front wings are almost wholly membranous. The Neuroptera, using the term in the Linnaean sense, are the least amenable to law; their fore wings are usually membranous, though the veins are generally thick and approximated; a few (Ephemerina) have small hind wings; many of them show the regional divisions of the body almost as strikingly as the Metabola, although the abdomen is generally developed to an excessive extent, and in such insects the prothorax is not greatly developed: while, as before stated, part of them have an incomplete metamorphosis, and so have been classed with the Orthoptera by the later German writers, and others have an incomplete metamorphosis. The structural affinities, however, of the Neuroptera proper and the so-called Pseudoneuroptera are so close that they cannot be disconnected, notwithstanding the striking differences in general features between them; and although, thus composed, the Heterometabola exhibit anomalous features in nearly every suborder contained in it, we must accord to this division of hexapods into Metabola and Heterometabola a closer connection with all the facts than any that has yet been proposed.

How closely this division accords with the geological succession of insects will appear from the fact that all the suborders of Heterometabola, and none of Metabola are represented in the palaeozoic rocks.[2] This is the more striking from the fact that, if we omit mention of the single discovery of insect wings in the Devonian, the three orders of insects, — hexapods, arachnids and myriapods, appear simultaneously in Carboniferous strata.[3]

[1] It would appear, at first sight, as if Dr. LeConte, in his Classification of the Coleoptera of North America (8°. Washington, 1861). Introduction, p. 8, held that Coleoptera were to be ranked as the highest suborder among hexapods. His table would seem to indicate this; but he speaks with hesitation, as if proposing only a provisional arrangment, remarking: "We can merely state in general terms that those [hexapods] having a perfect metamorphosis are the highest; and those having the thoracic segments agglutinated, or the prothorax separate, are to be considered above those in which the larval character of similarity among the thoracic segments is preserved." To the first proposition no one will take exception; the latter ought to be restricted in its application to those groups only to which the Coleoptera are most nearly related, viz.; to the other Heterometabola; so far as they are concerned this would seem to be an indication of special and therefore comparatively high structure; but otherwise, as a mark of inferior organization, since it is opposed to the progress of structure seen throughout the articulates, marked by a condensation, so to speak, of the thoracic segments. Many Neuroptera and Orthoptera, notably such forms as Corydalis and Forficula (the latter classed by early writers with Coleoptera), show in their prothorax a close resemblance to Coleoptera; and the very size and importance of this segment in Coleoptera, when the whole hexapod series is taken into account, should therefore be looked upon as a sign of relatively low rank. I am pleased to be able to state, from a recent conversation on this point with Dr. LeConte, that he did not intend to extend the argument drawn from the prothorax over the whole hexapod series, but only over those most nearly related to Coleoptera, and purposely expressed himself in guarded language.

[2] No generalization so broad as this and at the same time correct has yet been made. Many authors indeed, and notably Bronn, dividing the hexapods into two series,—Mandibulata and Suctoria (or equivalent terms) — claim that the carboniferous hexapods were all biting insects, and that the sucking insects first appeared in the Jura. The latest statement of this sort was made by Haeckel (Gen. Morph. Organ., II, p. xcix, 1866), but Dohrn's Eugereon was published in the same year, and by the light of this strange insect many palaeozoic insects now appear, as I shall endeavor to show below, under an entirely new aspect, and render it probable that there were many, as there certainly were some, sucking insects in palaeozoic times.

[3] Carboniferous arachnids have been described by Corda, Frič, Harger, Meek and Worthen, Roemer, Scudder, and Woodward; while myriapods from the same formation have been described by Dawson, Meek and Worthen, Scudder, and Woodward; besides others from other palaeozoic beds by Dohrn and Geinitz.

The earliest known Diptera occur in the Liassic rocks at Cheltenham, Dumbleton and Forthampton in England; the Lepidoptera[1] in the middle Oolite (Solenhofen); and the Hymenoptera in the same formation.[2] The Metabola are then later in time and more perfect in development than the Heterometabola.

When we analyze the insect fauna of the earliest times more closely, we notice that the higher suborders of Heterometabola, the Coleoptera and Hemiptera, are represented in the palaeozoic rocks by very few types, as compared with the Orthoptera and Neuroptera; the two former groups having but three or four each,[3] while Goldenberg enumerates fifteen or sixteen of each of the others from Saarbrücken alone, and double that number must be known. No Coleoptera nor Hemiptera have yet been found in the palaeozoic formations of America, while I am acquainted with about forty Orthoptera and Neuroptera from these rocks. The almost entire absence of Coleoptera from palaeozoic rocks is the more remarkable, because their crust is much thicker than that of other insects, and their shards as hard as the shell of the body. This is peculiarly the case in the lowest and presumably oldest type, the weevils or Curculionidae. Their remains have been preserved with the greatest readiness in more modern strata; in fact, in all the newer rocks, Coleoptera are best represented of all insects; yet in the oldest, very few have been found in comparison with the remains of the lower suborders. This is a striking and indisputable fact, and notwithstanding the paucity of the material whereon to base a general statement, is scarcely to be explained on any other hypothesis than that of the later appearance of Coleoptera.

In the Orthoptera again, nearly all the families represented belong to the lower series; only four or five members of the saltatorial families have been found, the cockroaches of the Carboniferous period outnumbering all the other Orthoptera many times. In the last catalogue of fossil cockroaches (by Goldenberg), thirty-five species are recorded from the Carboniferous rocks and only seven from the Tertiary formation. Indeed about one-half the known species of palaeozoic insects are cockroaches.

Or, if we look at the Neuroptera, we find that the Neuroptera proper, or those with complete metamorphosis, scarcely occur at all in the palaeozoic rocks; whereas the lower Pseudoneuroptera, with incomplete metamorphosis, are comparatively abundant. Many of the reticulate-winged insects of early periods, however, combine the characters either of the Neuroptera and Orthoptera, or of the Neuroptera proper and Pseudoneuroptera. So striking, indeed, is the comprehensive nature of these early types that Dohrn, and after him

[1] The carboniferous Breyeria of de Borre (Comptes rend. Soc. Ent. Belg., [2.] XIII: 7–11) is universally conceded to be a neuropterous insect. See the remarks in the same journal by Hagen, Heer, McLachlan, de Selys, Scudder, Van Volxem and others.

[2] A single species, doubtfully referred by Heer to the latter suborder, has, however, been found in the Lias of Schämbelen.

[3] The only Coleoptera known to me are *Curculioides Ansticii* Buckl., from Coalbrook Dale, *Troxites Germari* Goldenb., from Altenwald, and the borings of a *Hylesinus* described by Brongniart as occurring in petrified wood from the carboniferous limestones of Autun. Geinitz also describes borings of a larger beetle in fossil wood from the Saxon coal measures to which Frič gives the name of *Xylorgetes planus*; and Sternberg others from Bohemia of a doubtful character, which Frič calls *Xyl. septarous*. *Curc. Prestvicii* Buckl. has been shown to be an Arachnid.

The only Hemiptera from these lowest rocks are *Fulgora Ebersi* Dohrn and *Fulgorina Klieveri* Goldenb., from Saarbruecken, and *Macrophlebium Hollebeni* Goldenb., from Manebach; besides *Fulgorina lebachensis* Goldenb., from the Permian. *Eugereon Boeckingi* Dohrn, cannot be classed here, as will appear further on.

Goldenberg, proposes to group them under a new subordinal division, to which Goldenberg has applied the name Palaeodictyoptera.[1]

This view I am inclined to think a correct one, but no definition of the group has yet been attempted; and while, on the one hand, Goldenberg appears to have gone too far in referring to it the Carboniferous insects from Illinois described by Dana, and the Devonian insects of New Brunswick, it would seem probable that Woodward's Archimantis[2] should be classed therein, as well as the genera Eugereon, Dictyoneura, Paolia and Haplophlebium; and it is by no means improbable that they all possessed mouth parts structurally comparable to the remarkable Eugereon of Dohrn, which certainly can be referred to no existing group of insects. When more of their structure is known, they will probably be found to agree in the possession of a remarkably depressed, cockroach-like body, with ample thoracic segments, the prothorax well separated from the other joints, broadly expanded or extended, reticulated wings, lancet-shaped mandibles and maxillae, long labial palpi which have no direct part in the haustellate structure of the mouth, and multiarticulate antennæ. This is a combination quite at variance with that of any group of recent or of newer geological times, and indeed is known to us only in the palaeozoic rocks. It forms a synthetic type in the largest sense, and may be said to combine features of all the Heterometabola.

But it was not the only such type then existing; for, as has already been noted, there are many other palaeozoic insects which combine in their structure features now characteristic of diverse groups. Such are nearly all the Devonian insects. It is also not a little remarkable to find that recent types existed in the earliest periods side by side with these. Some of the Devonian insects, for example, are to be referred with very little question, not only to the Neuroptera, but even to a particular family of Neuroptera now existing, the May flies. Indeed, the presence, at the apparition of a given group, of modern types, side by side with those which elude our classification of existing forms, is one of the peculiar problems of palaeontology.

Perhaps no more striking instance of this can be found than the recent discovery by M. Charles Brongniart, in the upper Carboniferous rocks of Commentry, of one of the most specialized forms of insects which exist; of a type indeed so modern, that, so far as I may judge from a rough sketch sent me by Brongniart, one would not have been surprised to meet with its exact counterpart in every detail, living in the tropics of the old world. It is a species of large, spinous, thick-bodied Phasma or walking-stick, with abbreviated tegmina, long wings and body, rather long and slender legs and antennæ, and in all its parts

[1] Cf. Dohrn, Palaeontogr., XIII: 338–39; XIV: 134. Goldenberg, Faun. Sar. foss., II: 8. Dohrn first proposed the term Dictyoptera, but afterwards withdrew it, as preoccupied.

[2] Woodward. On a remarkable orthopterous insect from the coal-measures of Scotland. < Quart. Journ. Geol. Soc. Lond., 1876, 60–64, pl. 9. Woodward, it seems to me, has in all probability mistaken the affinities of this insect. If his figure is placed beside Dohrn's first illustration of Eugereon, the similarity of the two will be apparent. The form and relations of the head, prothorax and broadly expanded wings (nearly all that is preserved in Archimantis) are the same in each, as well as, in a general sense, the neuration of the wings. The projection in front of the head, therefore, would seem to be, not a prolongation of the head itself, comparable, as supposed by Woodward, to that of the head of some living Mantidæ; but a rostrum, like that of Eugereon, though much shorter than it, and by its state of preservation apparently amalgamated with it into a single mass; or, it may be the labrum alone with the other parts removed, for it would then probably appear as an integral part of the head. The close relationship of the wing-structure in Archimantis, Eugereon and the other genera specified above render it not improbable that they were all sucking insects. Protophasma however, similarly related, certainly was not.

perfectly reproducing the customary and yet unique features of the Phasmida of to-day.[1] The family had not previously been known earlier than the Tertiaries.

We may glean still another fact from the scanty data the rocks afford us concerning the early types of insects. All the Hemiptera of the palaeozoic rocks belong to the Homopterous division of the suborder; indicating, what is generally conceded, that this division is lower than the Heteroptera, which first appeared in the Jura.[2] Now one conspicuous difference between these two divisions is found in the structure of the base of the front wings, which is coriaceous in the Heteroptera and membranous in the Homoptera; showing that differentiation of the front and hind wings is, as we should suppose it might be, a later development, the homogeneous condition preceding it. Among Orthoptera, none of the families, unless it be the walking-sticks, have more densely coriaceous fore-wings than the earwigs and the cockroaches. The earwigs first appeared in the Oolite; and while cockroaches were abundant from the earliest times, it is not, with one exception, until we reach the Lias that we find species with close approximation and multiplication of the veins of the front wings, giving them a coriaceous appearance. This exception, *Ledrophora Girardi*,[3] in which the veins are nearly obsolete, occurs in the Trias; and it is the earliest indication of any differentiation of the front and hind wings in cockroaches; for all the palaeozoic species had tegmina which were as distinctly veined as the wings, and could not, in any sense, be called coriaceous.[4] The same distinctness of the veins is apparent in all the other palaeozoic Orthoptera; so that, excepting the two species of Carboniferous Coleoptera and Protophasma (which do not appear to differ in this respect from living types), we may say that the wings of palaeozoic insects were homogeneous.

Inasmuch as we know the earliest insects principally from the remains of their wings, it is interesting to note in them a further striking fact. If we should formulate the charac-

[1] Since the above was written, I have received from M. Brongniart his final memoir on Protophasma (Note sur un nouveau genre d' Orthoptère fossile de la famille des Phasmiens — Ann. Sci. Nat., [6] VII, Art. 4), by which it appears that the wings must be excepted from the statement given above; for they differ remarkably from the wings of living Phasmida, and resemble extraordinarily the wings of Palaeodictyoptera, and especially those of Dictyoneura. They could not have been folded longitudinally to the degree that the wings of Phasmida are now plaited, for the anal area embraces less than one-third of the wings, and the interspaces between the veins of that part of the wing which lies above the anal area, are not straight but curved; in the number and arrangement of the veins in this upper part of the wing we have an almost exact counterpart of the wings of Dictyoneura; the same, to a less extent, may be said of the wings of the Fulgorina described by Goldenberg. This type of wing structure was therefore a very common one among palaeozoic insects, and accounts for Brongniart's suggestion, hardly to be received, that these Fulgorina should be considered Neuropterous; indeed the neuration of the wings of the numerous carboniferous Blattariæ does not lack a somewhat close adherence to the same type, and we may yet succeed in establishing an unusual degree of homogeneity in the wing structure of all or nearly all palaeozoic insects.

[2] Perhaps a similar statement may be made even of the few Coleoptera known. For, if we accept LeConte's primary division of Coleoptera into normal and rhynchophorous, the former the higher, and look upon the Troxites of Goldenberg, as I strongly incline to do, as a curculionid, — the only indication of the higher normal Coleoptera in the palaeozoic rocks will be the borings brought to notice by Geinitz, which were evidently made by a longicorn, a family of normal Coleoptera ranking rather low in the series.

[3] Heer. Ueber die fossilen Kakerlaken. < Vierteljahrschr. naturf. Gesellsch. Zurich, IX: 297, pl., fig. 5, 8?. Zurich, 1864.

[4] Exception should perhaps be made to the very remarkable cockroach described by Goldenberg (Faun. Sar. foss., I: 17, pl. 2, fig. 14, 14a), under the name of *Blattina insignis*; this insect has a slender, perhaps cylindrical, abdomen with tegmina and wings which appear to be equally leathery and in which nearly all trace of veins are lost. Here, however, all the wings appear to be alike in form, consistency and structure; and Goldenberg has given us only a meagre account of it, which is the more unfortunate, since it is second in interest only to Eugereon and Protophasma.

teristics of the wing structure of living insects (which show, indeed, a variety of type truly marvellous, and ranging from exceeding simplicity to a complexity which nearly baffles all attempts at homology), we should not need to modify our statement in the least particular to include the wing-structure of the insects of earliest times. The plan of neuration upon which the wings of insects were then constructed is the plan we find in all existing types. At the same time, as stated above in a note, there was an unusual degree of homogeneity in the wings of palaeozoic insects.

This review clearly indicates that the laws of succession of the insect tribes are quite similar to those which have long been known to hold in other groups of the animal kingdom: and that the facts are, in the main, such as the theory of descent demands. The exceptions to theory, however, and indeed the general facts, are such as to indicate that profound voids exist in our knowledge of the earliest history of insects. The appearance of hexapods in the middle Devonian long previous to any traces either of myriapods or of arachnids: the apparent advent of generalized groups of a comparatively narrow range, before those which are wider in scope and embrace the former; the apparition of Coleoptera, which present no indication of any divergence from the subordinal type, in Carboniferous beds first yielding an abundance of insect remains,—that is, as early as any insects whatever, excepting the homogeneous-winged Heterometabola of the Devonian; and the occasional discovery of highly specialized types at very early periods:—all point to the far earlier existence of widely comprehensive types, from which all these comparatively specialized but still more or less synthetic forms must have originated. The additions to our knowledge of palaeozoic insects within the past twenty years, and the increasing indications of dry land at earlier and earlier epochs,[1] must leave little doubt in the reflecting mind, not only that insects existed in no scanty numbers in Devonian and even in Silurian times, but that persistent research over wider fields will probably enable us, at no distant day, to replace hypotheses with facts.

In conclusion, we may recapitulate, as follows:—

1. With the exception of the few wings of hexapods known from the Devonian, the three orders of insects—hexapods, arachnids and myriapods—appeared simultaneously in Carboniferous strata.

2. Hexapod insects may be divided into a higher group (Metabola), including Hymenoptera, Lepidoptera and Diptera; and a lower group (Heterometabola), including Coleoptera, Hemiptera, Orthoptera and Neuroptera.

3. All Devonian and Carboniferous insects are Heterometabola, the Metabola making their first appearance in the Jurassic period.

4. Many synthetic or comprehensive types existed in palaeozoic times, combining the characters either of all the Heterometabola; of Orthoptera and Neuroptera; or of Neuroptera proper and Pseudoneuroptera.

5. The Devonian insects either belong to comprehensive types related to the two lower suborders only, or are low Pseudoneuroptera; and were undoubtedly aquatic in early life.

6. The lower suborders of Heterometabola,—Orthoptera and Neuroptera, were much more abundant in palaeozoic times than the higher,—Coleoptera and Hemiptera.

[1] Cf. Lesquereux. Land plants, recently discovered in the Silurian rocks of the United States. < Proc. Amer. Philos. Soc., XVII, No. 75, p. [illegible]. Philadelphia, 1877. On the first page of this paper will be found a résumé of our knowledge of this subject.

7. Nearly all the palaeozoic Orthoptera belong to the lower non-saltatorial families, and are almost exclusively cockroaches.

8. The Neuroptera proper were at that time much rarer than the lower Pseudoneuroptera.

9. All the earlier types were therefore of inferior organization.

10. The general type of wing structure in insects has remained unaltered from the earliest times.

11. With the exception of two species of Coleoptera and one of Orthoptera, the front and hind wings of palaeozoic insects were similar and membranous, heterogeneity making its appearance in mesozoic times. At the same time, the neuration of the wings of palaeozoic insects in otherwise widely diverse types was much more similar than now.

12. The series of facts presented to us by the progress of geological research leads to the conviction of the probable existence and possible discovery, in the Devonian and even in the Silurian formations, of winged insects, still more generalized in structure than any yet detected in the palaeozoic rocks.

It may also be added that nearly all the earlier insects were large, many of them gigantic in size, and, further, that there is a striking similarity between the carboniferous insect-fauna of Europe and North America.

NOTE. The preceding pages were printed before I chanced upon the following passage from Lacordaire (Introd. à l'entom. I, p. 326), which may be taken as a note to the last paragraph of third page of this paper: —

"Toutes les différences que l'on observe dans le thorax des Insectes proviennent du plus ou moins de développement qu'a pris chaque anneau thoracique, du nombre de pièces que chacun d'eux présente, et de la grandeur relative de chacune de ces pièces en particulier. Si le prothorax a acquis un développement extraordinaire, et s'est en quelque sorte séparé du mésothorax et du métathorax, on aura le thorax d'un Coléoptère, d'un Dermaptère, d'un Orthoptère et d'un Hémiptère. Si au contraire le prothorax est réduit à des dimensions très-exiguës, et que le mésothorax intimement uni au métathorax ait pris un accroissement énorme, on aura celui d'un Hyménoptère, d'un Lépidoptère et d'un Diptère."

III. Palaeozoic Cockroaches: A complete Revision of the Species of Both Worlds, with an Essay toward their Classification. By Samuel H. Scudder.

The study of fossil insects has hitherto furnished very little material toward a knowledge of the general laws which have governed the progress of animal life. The reason of this is not far to seek. The delicate nature of their framework is such that they are never found preserved in any abundance, and seldom in such condition as to preclude doubts as to their affinities; the number of extinct known forms bears, indeed, a very small proportion to that of other fossils. Moreover, the most important period in the history of any

Erratum for Vol. III, Part I, No. III, of the Memoirs of the Boston Society of Natural History.

By an unfortunate accident, three of the species described in this memoir have been ascribed to the wrong discoverer and to an incorrect horizon and locality. *Necymylacris heros* (p. 51, pl. 5, fig. 9), *Archimylacris parallelum* (p. 85, pl. 6, fig. 6), and the species described without a name (p. 128, pl. 6, fig. 13) were all discovered by Mr. R. D. Lacoe, and not by Mr. Mansfield, in the neighborhood of Pittston Penn. *Necymylacris heros*, like the single other species of the same genus, was found in a heavy black shale in the lowest productive coal measures, or the roof shales of vein C. *Archimylacris parallelum* and the other species came from Campbell's ledge, near the bottom of the interconglomerate (Rogers, No. XII). It is due to these gentlemen to state that the mistake is entirely mine.

SAMUEL H. SCUDDER.

Cambridge, Dec. 20, 1879.

one most likely to be fruitful in results.

Their remains were first made known by Germar[2] in 1842, in Count Münster's Beiträge zur Petrafactenkunde, where four species from Wettin were described and figured. Soon afterwards, in his general work on the fossils of Wettin and Löbejün, Germar redescribed these with as many more; and additional forms have been published from time to time by Goldenberg, Heer, E. Geinitz and others, until the number of European species at present recognized in the palaeozoic rocks is about forty. To find the original descriptions of these forty species one must look for no less than sixteen different papers by seven different writers: rarely, too, have any of them received any further study after their original description; it necessarily follows that our knowledge of them is very fragmentary, and a worse showing could be made were we to include the American species, of which descriptions of seven have appeared on six separate occasions.

[1] Compare this with the ratio of fossil to living mammals, as seen in the list given in Murray's Geographical Distribution of Mammals, pp. 320–64. 4°. London, 1866.

[2] One species had been previously described, but as a fern leaf.

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It is true that some slight suggestions have been made toward the classification of these insects, but, as will be shown further on, without much success. With rare exceptions all have been described under the generic term Blattina; the species, however, have occasionally been confounded, and their relationship to one another and to the cockroaches of later times has never been seriously examined. This examination seems the more desirable for two reasons. First: as a general rule, it is the upper wing of these creatures which has been preserved, allowing the best comparison not only with their living representatives, but with one another: for, owing to the transparency of the front as well as hind wings of palaeozoic insects, the venation is remarkably distinct, and from the nature of the part preserved is rarely displaced in fossilization. Second; our opportunities for any generalizations concerning palaeozoic insects are exceedingly limited; and this group, as the most abundant of all the ancient types, offers the most inviting field of research. It would appear, too, that the known species are in reality only the fragment of a vast host which existed at that time, but have left no further traces, a host so great as to render it suitable to characterize the carboniferous epoch, so far as insects are concerned, as the age of cockroaches.

This conclusion is drawn from two facts. Every new discovery of palaeozoic cockroaches, with scarcely an exception, reveals new species, so that upwards of sixty different kinds are enumerated in this paper, showing great diversity of structure, and seldom represented by more than a single specimen; this indicates that their petrifaction is a rare event, and that the few relics we have really represent a vast horde. The second fact is the decreasing representation of these insects in the rocks as we approach the present time, coupled with a very generous allowance of cockroaches living at the present day. If we divide the time which has elapsed since cockroaches appeared into three great divisions, corresponding to the palaeozoic, mesozoic and caenozoic epochs, embracing the present period in the last-named, we shall have, say, sixty species in the palaeozoic, thirty-five in the mesozoic and only sixteen fossil species in the caenozoic (even including those occurring in that most prolific insect-trap, the Prussian amber), with upwards of five hundred living species.[1] If we then consider the present as a part of the pliocene, and take only five hundred species as the number actually living in each of the three divisions of caenozoic time, making fifteen hundred in all, and sixteen as the number now reported as existing in tertiary times; and, finally, assume the same ratio between the unknown and the known to have held in the palaeozoic as in the caenozoic epoch, we shall have five thousand, six hundred and twenty-five species as the number of palaeozoic cockroaches. Even if enormously exaggerated, this estimate will at least indicate the prodigious quantity of cockroaches which then existed and give an additional reason for the present revision.[2]

Giebel, who published the first list of palaeozoic cockroaches, then supposed to be only eight in number,[3] brought them all under the generic term Blattina, and placed with them also some of the mesozoic species. In a foot-note (p. 315) he promises to give a "careful revision" of all the Wettin cockroaches, but this he has never done.

Heer, in his catalogue of fossil cockroaches,[4] was the first to attempt any division of the palaeozoic forms; his classification was as follows:—

[1] [illegible] estimate of existing types. Brunner [illegible] four hundred species, and [illegible] family have been [illegible]

[2] [illegible] the early appearance and [illegible] the cosmopolitan distribution and vexatious fecundity — the domination in short — of certain existing species of cockroach.

[3] Giebel. Die Insecten und Spinnen der Vorwelt. 8°. Leipzig, 1856. pp. 313–16.

[4] Heer, Vierteljahrschr. naturf. Gesellsch. Zurich. Jahrg. ix. pp. 28 *et seq.* (1864.)

Div. a. Reticulation tetragonal; main veins free. (9 species.)
Div. b. Main veins connected at the base. (1 species.)
Div. c. Reticulation polygonal; main veins free. (2 species.)
Div. d. Hind wings. (2 species; one wrongly placed here.)

The only other classification which has been attempted is that recently made by Goldenberg,[1] which is merely an extension of Heer's. He first separates those of the true carboniferous series from those occurring in the dyas, and for the former offers the following scheme:

Winged;	fore-wings membranous with distinct venation;	principal veins free;	with simple quadrangular cells arranged in rows;	Group I. (11 sp.)
			with polygonal cells;	Group II. (18 sp.)
		principal veins connected at the base;		Group III. (1 sp.)
	fore wings coriaceous, with indistinct venation;			Group IV. (1 sp.)
Wingless;				Group V. (1 sp.)

The few species from the dyas are divided into that from Weissig (1 sp.), and those from Lebach (2 sp.), and the latter are placed severally in groups corresponding exactly to Groups II. and III. of the carboniferous series.

Nearly all the species represented by fore-wings, whether in the classification of Heer or of Goldenberg are grouped, then, according to whether the minute cross-venation or reticulation of the wings is composed of polygonal cells or simply of cross veins running directly from one nervule to another. There are three serious objections to the naturalness of such a classification. First, it assigns a high importance to a necessarily insignificant feature in the structure of the wing. Second, the reticulation is frequently invisible either from its actual absence or the imperfect preservation of the fossil. And third, the same wing exhibits, certainly in some American species (e. g., *Etobl. venusta*, *E. Lesquereuxii*), a transverse reticulation in one part of the wing, and a honeycombed reticulation in another. We may therefore fairly set aside these classifications as insufficient and unsatisfactory.

More than ten years ago, in studying the first fossil cockroaches that came under my observation, and noticing the diversity of structure in the wings of palaeozoic species, I described two types under new generic names; but on the discovery and separate description of additional forms, it seemed best to revert to the common custom of referring all to Blattina until the present revision or some other was attempted.[2] A considerable number of new and interesting forms having recently accumulated, it seemed a favorable opportunity to pass the entire series under review; accordingly the illustrations of the described European species were copied and brought, as given in the plates, to the same scale (× 2 diam.), and, when necessary, so reversed as to place the costal margin on the left, the base of the wing being uppermost. This renders comparison more direct and simple, and in such as have been reversed it is merely the same as if one looked at the wing from the opposite surface.

A comparison of these with American types at once showed that, among the latter at least, a remarkable degree of diversity obtained, necessitating the division of the palaeozoic cockroaches into two tribes, according to the structure of the uppermost vein of the front wing; this vein, in one tribe, exclusively American, being composed of a series of long

[1] Goldenberg. Fauna saraepontana fossilis. Heft 2, pp. 18–20. 4°. Saarbrücken, 1877.

[2] Canad. Naturalist (2) VII, 271.

and unequal rays spreading from a common base, much like the rods of a fan; while in the other, found on both continents, the shorter and equal rays originate at regular intervals, as branches from the side of a main vein. No such important distinction exists in the cockroaches of the old world coal-measures, even in the most aberrant types; but within each of these two tribes, other distinctions appear, in the relative extent or position of the different areas, in the mode of branching of the main veins, or in the point of origin of the branches, affording valuable data for generic distinctions, and a tolerably safe clue, it is believed, to the true relationship of the species.

The classification proposed in this paper, based upon the structure of the framework of the wing, and generally neglecting its mere form or surface sculpture, may be expressed briefly by the scheme on the opposite page, which will be more fully developed in the body of the memoir.

A word may be said concerning the nomenclature employed in this scheme. It will be noticed that the generic term Blattina, first employed for palaeozoic cockroaches by Germar and since universally adopted in the same sense, has been dropped. It is not a little curious that the first four species described by Germar (and, I may add, the first American palaeozoic cockroach, described by Lesquereux) all belong to a single genus as here defined, namely Etoblattina, a genus at the same time the richest in species; so that there can be no doubt whatever as to which of these genera should bear the old name, if any of them can do so. It were indeed to be wished that it might be retained by Etoblattina, and to preserve the old name as far as possible I have retained it as a part of all the compound terms I have employed to designate the genera represented in the European carboniferous fauna, as well as in the tribal name which embraces them. But before Germar made this use of the term Blattina, earlier indeed by about thirty years,[1] he applied it to a cockroach from amber, which must be employed as the typical species, and which is utterly distinct from any of the palaeozoic forms. We are therefore unwillingly compelled to reject the name for palaeozoic cockroaches, and, unless indeed it be a synonym of some earlier name, to employ it for the tertiary Blattarian only.[2]

The use of the term Palaeoblattariae for all the palaeozoic cockroaches to distinguish them from more modern types requires also an explanation. In commencing this investigation it was anticipated that the mode of distribution of the principal veins of the wing and the relative area occupied by each would furnish some ground for discussing the affinities and natural classification of these animals and of separating them into genera and species. But the degree of divergence from living types which the palaeozoic forms exhibit, and their own division into two large groups was entirely unexpected. To appreciate the former distinctions, it will be best first to examine the wings of living Blattariae.

The structure of the organs of flight in cockroaches has received an unusual share of attention, principally from Messrs. Brunner and de Saussure, who have devoted a great

[1] Germar. Mag. d. Entom. Jahrg. I, 16 (1813).

[2] In his first use of the term Blattina, Germar employed it without any explanation whatever. In his work on Wettin fossils (p. 81), he says: "Blattinae nomine utimur, quo omnes species complectimur, quae antehac ad Blattae genus relatae." Goldenberg (Palaeontogr. IV, 5) was the first to define the genus, as follows: "Venis omnibus areae analis hemelytri in marginem internum excurrentibus." In it he placed *Etobl. primaeva*, *Hermatobl. lebachensis* and *Petrabl. gracilis*. Goldenberg (*loc. cit.*) further credits Berendt with the first use of the term, but I cannot discover that Berendt used it either in 1830 or in 1836, the two occasions when he referred specially to fossil cockroaches; while Germar certainly employed it in 1813. Nor did Berendt use it in 1845 in the essay prefixed to his Organische Reste im Bernstein.

PALAEOBLATTARIAE.

Tribe I. *Mylacridae*. Branches of the mediastinal vein arranged in a radiate manner, mostly springing from a common point at the base of the wing; mediastinal area subtriangular, uniformly tapering apically. (3 genera. American.)

- All the branches of the mediastinal vein arising close to the base of the wing.
  - Wings broad. Mediastinal and scapular areas together occupying less than half the wing. Externomedian area tolerably large, expanding regularly beyond the first branch. **Mylacris.** (5 species).
  - Wings slender. Mediastinal and scapular areas together occupying more than half the wing. Externomedian area small and compressed, scarcely expanding apically. **Lithomylacris.** (3 species.)
- Some of the apical branches of the mediastinal vein arising beyond the base of the wing and scarcely partaking in the radiate arrangement of the others. **Necymylacris.** (2 species.)

Tribe II. *Blattinariae*. Branches of the mediastinal vein arising at regular intervals from a principal stem; mediastinal area generally band-shaped. (8 genera. Both worlds.)

- Internomedian vein terminating beyond, rarely at, the middle of the outer half of the wing. Scapular and externomedian areas together covering less than one half of the wing.
  - Mediastinal area comparatively short, rarely exceeding, seldom equalling two-thirds the length of the wing.
    - Scapular area not reaching the tip of the wing, the extremity of the main vein curving upward. Externomedian area comparatively large. **Etoblattina.** (20 species. Both worlds.)
    - Scapular area extending beyond and embracing the tip of the wing, by the backward sweep of the main vein. Externomedian area comparatively small. **Archimylacris.** (2 species. American.)
  - Mediastinal area long, usually at least three-fourths the length of the wing, sometimes nearly reaching the tip.
    - Branches of scapular vein superior.
      - Externomedian branches inferior, so that the nervules divaricate on either side of the scapular-externomedian interspace. **Anthracoblattina.** (7 species. European.)
      - Externomedian branches superior, so that the nervules divaricate on either side of the externomedian-internomedian interspace. **Gerablattina.** (12 species. Both worlds.)
    - Branches of scapular vein inferior. **Hermatoblattina.** (2 species. European.)
- Internomedian vein terminating before the middle of the outer half of the wing. Scapular and externomedian areas together covering more than half the wing.
  - Externomedian vein directed toward and terminating near the apex of the wing, its branches inferior.
    - Principal veins closely crowded in the basal half of the wing. Branches uniformly distributed all over the wing. Scapular area terminating above the apex of the wing. **Progonoblattina.** (2 species. European.)
    - Principal veins widely separated in the basal half of the wing. Branches much more closely crowded in some parts of the wing than in others. Scapular area terminating below the apex of the wing. **Oryctoblattina.** (1 species. European.)
  - Externomedian vein directed toward and terminating near the middle of the inner border of the wing, its branches superior. **Petrablattina.** (2 species. Both worlds.)

deal of study to this family,[1] and having used the tegmina and wings for systematic purposes, have examined an immense series of specimens. These authors distinguish in the tegmina four, in the wings five, principal veins, the distribution of which is pretty constant in their general features, variable in the details; and this permits excellent characters to be drawn for the separation of the genera, etc. The four veins of the tegmina are the mediastinal, the scapular, the internomedian and the anal.[2] The mediastinal vein runs from the root of the wing in a nearly straight course to about the middle of the costal border, throwing off branches to that border. The scapular vein extends to the tip of the wing in a nearly straight course and throws off toward the costal border a number of branches, which may be simple or forked and disposed with greater or less regularity; in some instances, especially toward the tip of the wing, it also throws out branches on the opposite side. The anal furrow is an impressed curved line, characteristic of cockroaches, running to the inner margin before the middle of the wing; within the area thus marked off at the base of the wing are a number of simple or forked anal nervules, often curved, but always straighter than the anal furrow; these, although they impinge upon the latter, are to be considered branches of the anal vein, for they correspond to the radiate nervules of the longitudinally plicate portion of the hind wings. Between the scapular and anal veins runs the internomedian vein, an irregular nervure, the branches of which may be inferior or superior, longitudinal or oblique, simple or forked, and it is here therefore that the greatest variation in the manner of distribution occurs, although the relative extent of all the fields may greatly vary.

The hind wings have two features which are different from what we find in the tegmina; the first is the great expansion of the anal area, the innermost nervule of which is not developed as a furrow; the second is the presence of a new and distinct vein, the externomedian, lying between the scapular and the internomedian. There is no doubt that in the tegmina this vein should be regarded as amalgamated with the scapular vein, and the branches occasionally found near the apex of the tegmina, parting from the so-called scapular vein and terminating on the inner or apical margin (e. g., Chorisoneura), as the branches of the externomedian vein; the more so since in some genera (Ectobia, etc.) the internomedian vein is also amalgamated with the scapular, so that the so-called scapular vein appears to throw branches indifferently to one side or the other of the wing.

This curtailment or disappearance of the externomedian vein is due according to Saussure to the contraction of the tegmina. In comparing the tegmina with the wings, he remarks: "La portion de l'organe [i. e. the tegmina] située en arrière de la nervure humérale [scapular vein] s'est tellement contractée que le champ anal a pénétré dans le champ discoïdal [internomedian area] et se trouve un peu enveloppé par celui-ci. En y pénétrant, il l'a étranglé à la base, en refoulant la veine discoïdale [internomedian vein] contre la nervure humérale [scapular vein], en sorte que ces deux nervures se confondent à la base; et il s'est rétréci lui-même. Dans cette contraction, l'aire vitrée [externomedian area] a disparu."[3] We should be careful however not to give Saussure's words a meaning they were not intended to convey; the broadly expanded plicated area of the hind wings

[1] Brunner, Nouv. [illegible] Système des Blattaires, 8°. Vienne, [illegible] — Saussure, [illegible] Études sur l'aile des Orthoptères [illegible] Ann. Sc. Nat. [5] Zool., x, pp. 161, seq.; — Ib., Orthop- [illegible] Genève, 1864, pp. 16–28. — Ib., Miss. Scient. au Mexique, Ins. Orth. 4°. Paris, 1870, pp. 1–8.

[2] This is Heer's terminology, not Brunner's nor Saussure's.

[3] Ann. Sc. Nat. [5] Zool., x, p. 196.

is with little doubt a comparatively late development, and we may not look upon the tegmina as a contracted form of the wings; but rather, at the disappearance of the externomedian vein in the tegmina as one stage in the increasing heterogeneity of the organs of flight, as we pass from ancient times to the present; indeed the hind wings of insects in general contain far more indications of the earlier structure and ornamentation of the wings than the front pair.[1] As one example of this we find that the externomedian vein was perfectly developed in the front wings of all the palaeozoic cockroaches, and although probably some of the different nervures were sometimes blended at the base (e.g., *Etoblatt. russoma*, *Petrabl. gracilis*), apically each vein was always developed quite separate from the others.

This is a distinction of prime importance, and so far as we can discover, there is not a single exception in ancient or modern types. In all the palaeozoic species, the externomedian exists as an independent vein; in all modern species the vein itself is blended with the scapular, and can only be occasionally recognized near the extremity by its branches.

Besides this difference there is another which, although of less importance, is perhaps as constant and certainly is significant. In palaeozoic cockroaches the anal veins of the fore wing, as first noted by Goldenberg, impinge upon the border, just as they do in the few hind wings which are preserved. In living cockroaches, the branches of the anal vein in the hind wing, preserving here again the ancient characteristics, impinge upon the margin of the wing; while the specialization of the anal area of the fore wing — a distinctively Blattarian feature — has gone so far as to affect the direction of the veins, which do not impinge upon the border, but run parallel to it and strike the anal furrow.

For these reasons, as being of fundamental importance in the structure of the tegmina, and indicative of the profound changes the entire group of cockroaches has undergone since its origination, it appears necessary to separate the palaeozoic cockroaches from those existing at the present day as a distinct subfamily type.

In reviewing the existing species, in order to obtain some clue among them to the nearest allies of the palaeozoic cockroaches, it would appear that very little resemblance exists between the fore wings of the ancient species and those of the *Blattariae spinosae*, as compared with those of the *Blattariae muticae*. Further than this it would perhaps hardly be possible to go, unless indeed we were to compare some of the Blaberidae of the present day, comprising the giants of the time, with some of the ancient types, which, while generally larger than recent forms, also often boast of their very great size. Unfortunately we know almost nothing of the structure of the legs in the ancient cockroaches; they have been preserved, so far as appears, in only one or two instances. In one, *Blattina Tischbeini*, Goldenberg speaks of a fragment of a hind leg, consisting of the femur and tibia with traces of spines (*Spuren von Dornen*); but as neither his illustration nor his description show whether the spines occur on the femora or on the tibiae, we have no proof as to whether the former should be considered *spinosae* or *muticae*. In the illustration of the other (*Anthracobl. sopita*) no spines appear; and the describer of this species, Dr. E. Geinitz, gives no further account of the legs than their size; perhaps their preservation allows of no further statement, but this point should be studied.

[1] This point, which I hope to expand and illustrate on another occasion, is what might well be expected when we reflect how commonly the hind wings of insects are concealed by the front pair, when the insect is at rest.

Let us now examine the neuration of the wings of cockroaches with special reference to its development, in order to determine which of the two tribes into which we have divided the Palaeoblattariae is to be considered the more primitive type. At the outset we may remark that were we to base our ideas of the relative rank of the existing suborders of insects upon the degree of complication of the neuration of their wings alone we should undoubtedly fall into error. Yet, although in studying the most ancient insects this portion of their structure is nearly all we have to guide us, we may confidently assume that it is here sufficient to determine their relationship with accuracy. The variation in the structure of the wings of existing insects is the result of a multitude of forces exerted through aeons, and exhibits every imaginable form from extreme simplicity to excessive complexity: in some insects the wings, like the rest of the body, have retained an ancient simplicity of structure, as in the May-flies; in others they appear to have lapsed into simplicity, or to have retained a simple distribution of the veins, when the other parts of the body have become highly organized, such as the Lepidoptera generally; in still others, by the diversity of use to which the wings have been put, they have become in different ways extremely complicated, so that the plan of neuration is greatly disturbed or nearly lost; as in the hind wings of earwigs, and of many cockroaches and beetles, and in both wings of dragon flies, — nearly all of which insects are otherwise lowly organized.

This differentiation of the neuration, we may judge by many proofs,[1] had made slight progress in palaeozoic times. The wings of the then existing insects were comparatively simple and uniform. Nevertheless, the variation of structure was already sufficient in the carboniferous epoch to prove that we must look far back of it for the origin of winged insects. We have already shown that differences existed among cockroaches warranting their division into two great groups; and as a whole this family group was distinctly separated, even at that early time, from all other insects, even as they are to-day, unless we except their nearest allies the Mantidae, in the burial of the innermost anal vein at the bottom of a deep sulcation, dividing the anal area from the rest of the wing. They were also peculiar — although a few ancient types partially shared with them this characteristic — in that the large number of mediastinal branches, as well as the main mediastinal vein, terminate on the costal margin only, and do not leave it simply supported by the main vein lying in close proximity. This peculiarity necessitated a somewhat central origin for the veins at the base of the wing, and apparently led to the diversity noticed in the two types of ancient cockroaches.

If we were to express in simplest terms the structure of a symmetrically developed wing (like that of the palaeozoic cockroaches with its five principal branching veins), we should figure the middle vein as running straight to the apex, forking as it went and occupying the apical margin with its branches; while the similarly forking branches of the upper two veins would curve toward and terminate upon the costal margin, and those of the lower veins upon the inner margin. A wing has already been found[2] quite as simple in idea as this, but belonging to the other group of palaeozoic insects, in which the wing is not symmetrical, but where all the veins and their branches impinge upon the inner and apical margin of the wing. In such a wing, differentiation of the veins may scarcely be said to

[1] See the preceding paper: The early types of insects.

[2] Scudder. An insect wing of extreme simplicity from the coal formation. < Proc. Bost. Soc. Nat., Hist. XIX, 248–49.

exist; the second repeats the first, and the fourth the fifth, a little further removed from the base, while the third vein, filling the space between the second and fourth, differs from them only by its straightness and apical termination; the general resemblance of each to the others is very close. Yet one has scarcely more to do than to deepen the inner anal vein, and perhaps remove the main veins a little nearer the costal border, giving a very slight asymmetry to the wing, to impress upon such an ideal wing distinct blattarian features; for in all the palaeozoic cockroaches, partially excepting Oryctoblattina, the distribution of the scapular branches more or less resembles that of the mediastinal, and that of the internomedian the anal, while the externomedian branches occupy the middle ground and the apex of the wing, seldom swerving to either side.

It is, however, highly probable that such an ancient wing was broad at the base, for this was the case with nearly all the palaeozoic insects, and certainly, which is more to our purpose, with all the carboniferous cockroaches; it is furthermore a characteristic of the cockroaches of the present day, and therefore all the more probably of high antiquity. In this case the mediastinal and anal areas must have been more broadly triangular in shape than the neighboring areas, and their veins consequently arranged in a more radiate fashion, the different branches arising close together from a common base; while in the neighboring areas they would naturally arise at intervals from a main stem. This condition is precisely that of the Mylacridae and would naturally precede that in which the mediastinal vein, to strengthen the part of the wing most liable to strain, follows the basal curve of the costal margin and throws its branches off at intervals toward the border, heightening at the same time the resemblance between the distribution of the branches in the scapular and mediastinal areas; a tendency to this appears in Necymylacris and it is fully developed in the Blattinariae. That the anal vein has not followed the same rule is doubtless due, partly to the small need of special support for the lower base of the wing, and partly to the deep impression of the inner anal vein, which has forced, as it were, the other branches to ally themselves with it.

This view of the relative primitiveness of the two types of ancient cockroaches is strengthened by noticing the further differentiation of the tegmina in modern times, where the only remaining relic of repetition of characters in adjoining areas is the resemblance of the disposition of the scapular and mediastinal branches; and even this resemblance recalls the features of the Blattinariae, rather than of the Mylacridae. In all the Palaeoblattinariae, so far as we know them, (excepting perhaps in Oryctoblattina,) the internomedian veins have the same general tendency to repeat the downward and outward curve of the anal veins as we find in the corresponding veins of the costal region. But in recent cockroaches, not only do the anal veins run parallel to the inner margin and impinge upon the anal furrow, but the internomedian veins may branch in any direction, so varied has the plan of distribution grown; in general however the internomedian vein may be said to have assumed in modern types the rôle played by the externomedian vein in the Palaeoblattariae; and in not a few instances in the ancient types there is a marked tendency of both the scapular and internomedian veins, especially toward the apex of the wing, to assume a mode of distribution more closely resembling that of the externomedian than of the mediastinal and anal branches respectively. Indeed the similiarity of the distribution of the veins in the scapular and externomedian areas has induced me to place Hermatoblattina and Progonoblattina near Oryctoblattina high in the series. Petrablattina has also been placed very high, on account of the apparent amalgamation of all the principal veins next the base, as they generally appear in modern types.

On zoological grounds, then, we should look upon the Mylacridae as the older type, but when we come to examine the geological record, we discover very little special correspondence between these features of structure and the relative age of the insects in question. Our oldest American species are *Gerablattina fascigera* and ***Petrablattina sepulta***, and probably *Blattina venusta*, all of which are Blattinariae, not Mylacridae; the other American members of the group of Blattinariae are found in all the rocks up to the permo-carboniferous, while the Mylacridae are confined to the true coal-measures, unless ***Necym. heros*** and *Archim. parallelum* fall below them. On the other hand, it is worthy of remark that of the nine species placed highest in the entire series below, before their stratigraphical position was at all considered, and belonging to five distinct genera, ***Petrablattina gracilis***, *Hermatoblattina lebachensis* and perhaps *Gerablattina balteata* belong to the permian or dyassic formation, and comprise nearly one half of the species certainly known from that horizon. And it will be seen further on that much the largest percentage of the European cockroaches (Blattinariae only) come from the upper carboniferous beds; of the American (Mylacridae and Blattinariae) from below them. It must not be overlooked however that the great mass of palaeozoic cockroaches as a whole come from the highest carboniferous rocks, and that the stragglers that have been found below these uppermost beds are far too few for us to base any safe generalizations upon them.

As to the geological range of the species, it would appear as if it were always extremely limited, did we not reflect that very few of the species are known by more than one example. It has been claimed by Dr. E. Geinitz that five of the species first described from the carboniferous series, viz.: *Etobl. anthracophila*, *Etobl. carbonaria* and ***Etobl. didyma*** of Wettin, *Anthracobl. spectabilis* of Löbejün, and *Gerabl. Mahri* of Manebach, all from the uppermost carboniferous rocks, were also found in the lower dyas of Weissig. He supports his statement by figures or descriptions in three instances, and in each of these cases I shall show that the reference was incorrect: *Etobl. didyma* being referred below to a distinct species, *Anthracobl. sopita*; *Etobl. anthracophila* to *Etobl. flabellata*; and *Gerabl. Mahri* to a second distinct species, *Etobl. elongata*. This result throws some doubt upon the unsupported references in the two other cases, and while these remain in doubt,[1] *Etoblattina flabellata* is the only species unquestionably found in both the carboniferous and dyassic series of the old world. The only other European species said to have been found at two distinct localities is *Etobl. didyma*, which Germar described from Wettin and Mahr says has been repeatedly found at Ilmenau; but these places are at the same horizon.

In the new world the only instance of the discovery of a second specimen of any species is in the presumed case of *Gerablattina balteata*, where one was found in what are termed permo-carboniferous rocks, on account of some question as to their true horizon, and the other in undoubted uppermost carboniferous rocks. The so-called permo-carboniferous rocks, however, are deemed by some geologists as certainly upper carboniferous.

[1] Geinitz himself refers to *Anthrac. spectabilis* with a query.

Few of the genera appear to be confined to very narrow geological limits excepting those which are poor in species. Mylacris (5 sp.) however is only found in the lower or middle carboniferous series, as is also Necymylacris (2 sp.) and Archymylacris (2 sp.). Gerablattina (12 sp.), Progonoblattina (2 sp.) and Oryctoblattina (1 sp.) are the only European genera not occurring in the dyas and the first of these occurs in the permo-carboniferous of America; but Anthracoblattina (7 sp.), though occurring throughout the range of cockroaches in the European palaeozoic rocks, has its largest development (5-6 sp.) either in the dyas or in the very highest of the upper carboniferous beds.

The following table represents the cockroach fauna of the different localities in the palaeozoic beds of Europe, the two doubtful species of Weissig being placed in brackets.

DYAS.

Weissig, Saxony.

Etoblattina flabellata.	[Anthracoblattina spectabilis.]
" weissigensis.	" sopita.
[" carbonaria.]	" porrecta.

Lebach, near Saarbrücken, Rhenish provinces of Prussia.

Hermatoblattina lebachensis.	Petrablattina gracilis.

Stockheim, Bavaria.

Anthracoblattina Ruckerti.

CARBONIFEROUS.

Saarbrücken (immediate vicinity), Rhenish provinces of Prussia.

Etoblattina primaeva.	Anthracoblattina winteriana.
" labachensis.	Gerablattina intermedia.
" insignis.	" scaberata.

Hermatoblattina wemmetsweileriensis.

Saarbrücken (basin).

Anthracoblattina Remigii (Cusel, Rhenish Bavaria).	Gerablattina weissiana (Brücken, Waldmohr, Rhenish Bavaria).

Manebach, near Ilmenau, Saxe Weimar.

Etoblattina didyma.	Gerablattina clathrata.
" manebachensis.	" Mahri.
Gerablattina Goldenbergi.	Progonoblattina Fritschii.

Wettin-Löbejün, Prussian Saxony.

Etoblattina euglyptica.	Etoblattina russoma.
" affinis.	" leptophlebica.
" flabellata.	" parvula.
" anthracophila.	Anthracoblattina spectabilis.
" Dohrnii.	Gerablattina Geinitzi.
" anaglyptica.	" Münsteri.
" carbonaria.	" producta.
" didyma.	" Germari.

Oryctoblattina reticulata.

Klein-Opitz, near Dresden, Saxony.
Anthracoblattina dresdensis.

Erbignon, Switzerland.
Progonoblattina helvetica.

Durham, England.
Etoblattina mantidioides.

The following table, mainly based on the "Chronologische Uebersicht des Steinkohlen-Ablagerungen in Europa", given by Dr. H. B. Geinitz in Geinitz, Fleck u. Hartig: Die Steinkohlen Deutschlands. 4°. München, 1865, may serve to indicate the probable relative age of the European species. The carboniferous beds are divided by him into five zones, as follows, commencing at the base: I. Hauptzone der Lycopodiaceen; II. der Sigillarien; III. der Calamiten; IV. der Annularien; V. der Farren. The two dyassic species enclosed in brackets are those credited by Dr. E. Geinitz to this formation. Perhaps all the carboniferous species should be classed together as upper carboniferous, excepting the three placed under zone II-III; and these to the middle carboniferous.

LOWER DYAS.

Etoblattina flabellata.	(Weissig.)	Anthracoblattina sopita.	(Weissig.)
" weissigensis.	(")	" porrecta.	(")
[" carbonaria.]	(")	" Rückerti.	(Stockheim.)
" elongata.	(")	Hermatoblattina lebachensis.	(Lebach.)
[Anthracoblattina spectabilis.]	(Weissig.)	Petrablattina gracilis.	(")

UPPER CARBONIFEROUS

CARBONIFEROUS ZONE V.

Etoblattina didyma.	(Manebach.)	Gerablattina Goldenbergi.	(Manebach.)
" manebachensis.	(")	" clathrata.	(")
Anthracoblattina dresdensis.	(Klein-Opitz.)	" Mahri.	(")
" Remigii.	(Cusel.)	" weissiana.	(Brücken.)
Progonoblattina Fritschii.	(Manebach.)		

CARBONIFEROUS ZONE IV–V.

Etoblattina primaeva.	(Auerswald.)	Etoblattina leptophlebica.	(Löbejün.)
" labachensis.	(Labach.)	" parvula.	(")
" euglyptica.	(Wettin.)	Anthracoblattina spectabilis.	(")
" affinis.	(Löbejün.)	Gerablattina intermedia.	(Wemmetsweiler.)
" flabellata.	(Wettin.)	" Geinitzi.	(Löbejün.)
" anthracophila.	(")	" Münsteri.	(Wettin.)
" Dohrnii.	(")	" producta.	(")
" anaglyptica.	(")	" Germari.	(")
" [illegible]	(")	Hermatoblattina wemmetsweileriensis.	(Wemmetsweiler.)
" didyma.	(Wettin.)		
" russoma.	(Lobejun.)	Oryctoblattina reticulata.	(Wettin.)

CARBONIFEROUS ZONE II–V.

Etoblattina mantidioides.	(Durham.)	Progonoblattina helvetica.	(Erbignon.)

MIDDLE CARB.

CARBONIFEROUS ZONE II–III.

Etoblattina [illegible]	(Saarbrücken.)	Anthracoblattina winteriana.	(Dudweiler.)
Gerablattina scaberata.	(Altenwald.)		

The American species come from the following localities, the Mylacridae being placed in the left hand, the Blattinariae in the right hand column.

ACADIAN COAL-FIELD.

Sydney, Cape Breton.	
Mylacris bretonense.	Petrablattina sepulta.
" Heeri.	
Pictou, Nova Scotia.	
	Archymylacris acadicum.

APPALACHIAN COAL-FIELD.

Cannelton, Beaver Co., Penn.	
Mylacris pennsylvanicum.	Archymylacris parallelum.
" Mansfieldi.	
Necymylacris heros.	
Pittston, Luzerne Co., Penn.[1]	
Lithomylacris angustum.	Etoblattina Lesquereuxii.
" pittstonianum.	Gerablattina fascigera.
Necymylacris lacoanum.	
Cassville, W. Virginia.	
	Gerablattina balteata.
Bellaire, Ohio.	
	Gerablattina balteata.

EASTERN INTERIOR COAL-FIELD.

Danville, Ill.	
Lithomylacris simplex.	
Colchester, Ill.	
Mylacris anthracophilum.	

WESTERN INTERIOR COAL-FIELD.

Frog Bayou, Arkansas.	
	Etoblattina venusta.

The correlation of the beds in the Eastern border and Interior basins of N. America is not yet satisfactorily accomplished. The period of the deposition of the millstone grit in the interior basin may even possibly be synchronous. I am informed by Professor N. S.

[1] Concerning the localities in the vicinity of Pittston, Mr. R. D. Lacoe, to whom I am indebted for all the specimens described from there, writes me that the shale containing *Etoblattina Lesquereuxii* was picked up in the vicinity of Pittston, in a pile of culm or impurities from a mine; the exact locality was unknown to him, but from the character of the slate he had no doubt of its being from the roof shales of the D seam of anthracite coal. *Lithomylacris angustum* and *L. pittstonianum* are from the roof shales of the E seam of coal, which when unaffected by weathering much resemble the shales of the D seam, but is very rarely so highly impregnated with carbon. The specimens came from Port Griffith at the outcrop of the shales at one of the principal anticlinals that cross the otherwise quite level coal field, and once apparently formed long narrow islands in the carboniferous lake, against the southeastern side of which many small objects drifted and left their impress. *Gerablattina fascigera* was found by Mr. Lacoe in the anticlinal next north of the one first mentioned and also on the southeastern side. *Necymylacis lacoanum* comes from the lowest productive coal measures near Pittston.

Shaler, with some of the later coal deposits of the eastern border region; but assuming the millstone grit of the east and west to be of the same age, we may express tolerably well the general stratigraphical relations of the species by the following table:

		Base of Millstone grit.	*Top of Millstone grit.*	*Lower or Middle Coal Measures.*	*Upper Coal Measures.*	*Permo-carboniferous.*
MYLACRIDAE.	Appalachian coal-field.		Necymylacris heros.	Mylacris pennsylvanicum. Mylacris Mansfieldii. Necymylacris lacoanum.	Lithomylacris pittstonianum. Lithomylacris angustum.	
	Acadian coal-field.			Mylacris Heeri. Mylacris bretonense.		
	Eastern interior coal-field.			Mylacris anthracophilum. Lithomylacris simplex.		
BLATTINARIAE.	Appalachian coal-field.		Archimylacris parallelum. Gerablattina fascigera.		Etoblattina Lesquerenxii. Gerablattina balteata.	Gerablattina balteata.
	Acadian coal-field.		Petrablattina sepulta.	Archimylacris acadicum.		
	Western interior coal-field.	Etoblattina venusta.				

If we assume the separation between the upper and middle carboniferous to be correct, we shall have the following percentage of the species from the different formations in either country:

In Europe: Above the upper carboniferous 26 per cent.; in it 74 per cent.; below it 7 per cent.
In America: Above the upper carboniferous 6 per cent.; in it 24 per cent.; below it 76 per cent.

Certain species appearing in the lists twice over make the totals of percentage in each case above 100. It would appear from this summary that the American cockroaches are the older, and a certain light is thus thrown upon the occurrence of Mylacridae in the New World only.

I have already given some reasons for believing, not only that cockroaches formed the majority of insects in palaeozoic times, but that the actual number of species was very great. That they were also abundant in individuals is probable, judging from the present fecundity of their descendants and from a few other facts. Goldenberg, for instance, remarks (Faun. Saraep. foss. I, 17) that where one finds any remains of cockroaches in the palaeozoic rocks, one nearly always discovers more than a single fragment; at least this was the case with *Etoblattina primaeva*, *E. lebachensis* and *Blattina Tischbeini*; and he judges from this, that, as at the present time, these creatures collected in numbers in a single spot: but it seems rather to indicate merely the great numbers of individuals which then existed. Goldenberg elsewhere remarks (Faun. Saraep. foss. II, 21) that cockroaches formed nearly one-half the insects of the coal period, reaching then their greatest development. He finds reasons for this, first, in the warmth and obscurity of the forest vegetation of that time, which only suited such animals as these; and second, in the intimate correlation between the insect world and the plant world, by which the former finds its principal nourishment in the latter. Such a food-plant for the palaeozoic cockroach he would discover in the tree-like Noeggerathia, or the Cordaites of the period; just as the ally of the former, the sago palm, furnishes food to the cockroaches of to-day. Heer also relates, in his essay on fossil cockroaches, that the botanical garden at Zurich accidentally imported from Cuba cockroaches in all stages of development in stems of Cycads, and thereupon suggests that Noeggerathia might very probably have been the food of palaeozoic cockroaches. I have also described a species of Platyzosteria (*P. sabalianus*) which lives in the tops of the cabbage palmetto, *Sabal palmetto*. We thus arrive at some indications of the manner of life of these ancient creatures.

Heer believes the scantiness of our knowledge of fossil cockroaches to be due to the slight attention that has been paid to them, and that in the mass of plants which have been exhumed from the coal beds, many more will be found when these have been carefully examined with this in view. At the time he wrote not a single species of cockroach had been found in more than one spot (and at Wettin and Manebach they formed almost or quite the only insects found there) while many species of plants were common to the different beds from which cockroaches had been exhumed. Notwithstanding the considerable increase of our knowledge since that time, this is almost as true now as then.

In this paper we have discussed almost exclusively the front wings of the palaeozoic cockroaches. In an appendix, however, those species which have been described from other fragments are reviewed and the descriptions put into an English dress. These species are *Blattina Tischbeini*, *Bl. latinervis* and *Bl. venosa*, described from hind wings or very imperfect remnants of fore wings; and *Polyzosterites granosus*, a wingless species. *Acridites carbonaria*, first described by Germar as the wing of a saltatorial orthopteron and subsequently considered by him as the hind wing of a cockroach, possibly of *Etobl. didyma*, and so catalogued up to the present time, appears rather to be a neuropterous wing and therefore is not discussed here. Besides these a couple of obscure fragments from the American rocks are briefly noticed but without name. It only remains to give an alphabetical list of the former and present names of palaeozoic cockroaches, and the bibliography of the subject, before taking up the species in detail.

Synonymical Table of hitherto described Palaeozoic Cockroaches.

Archimylacris acadicum Scudd. = Archimylacris acadicum.
Blattidium mantidioides Gold. = Etoblattina mantidioides.
Blattina affinis Gold. = Etoblattina affinis.
Blattina anaglyptica Germ. = Etoblattina anaglyptica.
Blattina anaglyptica var. labachensis Gold. = Etoblattina labachensis.
Blattina anthracophila Germ. = Etoblattina anthracophila.
Blattina anthracophila Gein. = Etoblattina flabellata.
Blattina bretonensis Scudd. = Mylacris bretonense.
Blattina carbonaria Germ. = Etoblattina carbonaria.
Blattina clathrata Heer. = Gerablattina clathrata.
Blattina didyma Germ. = Etoblattina didyma.
Blattina didyma Gein. = Anthracoblattina sopita.
Blattina dresdensis Gein.-Deichm. = Anthracoblattina dresdensis.
Blattina euglyptica Germ. = Etoblattina euglyptica.
Blattina euglyptica Gold. fig. 8. = Etoblattina Dohrnii.
Blattina euglyptica Gold. fig. 9. = Gerablattina producta.
Blattina euglyptica var. weissiana Gold. = Gerablattina weissiana.
Blattina fascigera Scudd. = Gerablattina fascigera.
Blattina flabellata Germ. (Munst). = Etoblattina flabellata.
Blattina flabellata Germ. (Wettin). = Gerablattina Munsteri.
Blattina Fritschii Heer. = Progonoblattina Fritschii.
Blattina Geinitzi Gold. = Gerablattina Geinitzi.
Blattina Germari (Giebel) Heer. = Gerablattina Germari.
Blattina Goldenbergi Mahr. = Gerablattina Goldenbergi.
Blattina gracilis Gold. = Petrablattina gracilis.
Blattina Heeri Scudd. = Mylacris Heeri.
Blattina helvetica Heer. = Progonoblattina helvetica.
Blattina insignis Gold. = Etoblattina insignis.
Blattina intermedia Gold. = Gerablattina intermedia.
Blattina labachensis Gold. = Etoblattina labachensis.

Blattina latinervis Heer. = Blattina latinervis (hind wing).
Blattina lebachensis Gold. = Hermatoblattina lebachensis.
Blattina leptophlebica Gold. = Etoblattina leptophlebica.
Blattina Mahri Gold. = Gerablattina Mahri.
Blattina Mahri Gein. = Etoblattina elongata.
Blattina manebachensis Gold. = Etoblattina manebachensis.
Blattina parvula Gold. = Etoblattina parvula.
Blattina porrecta Gein. = Anthracoblattina porrecta.
Blattina primaeva Gold. = Etoblattina primaeva.
Blattina Remigii Dohrn. = Anthracoblattina Remigii.
Blattina reticulata Germ. = Oryctoblattina reticulata.
Blattina Ruckerti Gold. = Anthracoblattina Ruckerti.
Blattina russoma Gold. = Etoblattina russoma.
Blattina scaberata Gold. = Gerablattina scaberata.
Blattina sepulta Scudd. = Petrablattina sepulta.
Blattina spectabilis Gold. = Anthracoblattina spectabilis.
Blattina Tischbeini Gold. = Blattina Tischbeini (fragment).
Blattina venosa Gold. = Blattina venosa (fragment).
Blattina venusta Lesq. = Etoblattina venusta.
Blattina weissiana Gold. = Gerablattina weissiana.
Blattina weissigensis Gein. = Etoblattina weissigensis.
Blattina wemmetsweileriensis Gold. = Hermatoblattina wemmetsweileriensis.
Blattina winteriana Gold. = Anthracoblattina winteriana.
Mylacris anthracophilum Scudd. = Mylacris anthracophilum.
Polyzosterites granosus (Gold.) Jord. = Polyzosterites granosus (body).

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PALAEOBLATTARIAE.

Palaeozoic cockroaches; in which the fore wings are diaphanous, generally reticulated and nearly symmetrical on either side of a longitudinal middle line; the externomedian vein is completely developed and divides in the outer half of the wing, its branches generally occupying the apical margin. The internomedian area is broad at its base (beyond the anal area), rapidly tapers apically and is filled with oblique, mostly parallel veins, having nearly the same direction as the anal veins, which, like them, strike the inner margin.

Their bodies appear to have been flat, but slenderer than usual in cockroaches of the present day, the pronotal shield depressed, more or less elliptical, but sometimes longer than broad, the head partly concealed by it as in living types. They were of large size; but while the average was considerably above that of existing cockroaches[1] none were much larger than some S. American species of Blabera. Germar was the first to note the diaphaneity of the fore wings,[2] and Goldenberg the presence of the externomedian vein,[3] and the course of the anal branches.[4]

MYLACRIDAE.

In this group the mediastinal vein of the tegmina with its branches consists of a number of veins, simple or forked close to their origin, spreading in a fan shape and appearing to arise from a single point or near a single point close to the base of the wing; or in other words, the branches originate from the main vein close to its base and to each other, the outermost being much longer than the innermost, often double as long as it, and either straight or uniformly arcuate; the area of the vein is thus triangular and more or less than half as long as the wing. The character of the vein therefore much more nearly resembles that of the anal vein than of the others. The group is confined, geographically, to America, and the wings are a little stouter on the average than those of the Blattinariae, the breadth being usually contained in the length less than two and one half times.

Mylacris (*μυλακρίς*).

Mylacris Scudd., in Worth. Geol. Surv. Ill. III., 568-69 (1868).

The mediastinal vein of the upper wing consists of about five principal stems, two or three of which fork before the middle, all of them straight or very gently curved, the outermost extending half way or even more to the tip of the wing; the point from which the principal stems originate is either in the middle of the wing or nearer its inner than its costal margin. The scapular vein is always arched strongly at the base before branching, which it commences to do as soon as allowed by the branches of the mediastinal vein; it then runs subparallel to the costal margin always to the extreme tip of the wing; during the larger part at least of its course it runs very nearly along the middle line of the wing,

[1] The [illegible] length of the front wing appears to have [illegible]

[2] D[illegible] Ader[illegible], den wir . . . wahrnehmen, [illegible] vorweltlichen Arten pergament- [illegible] GERMAR, Verst. Steink. Wet- [illegible]

[3] [illegible] Bl[illegible] sich in diesem Felde [illegible] Mittelader wahrnehmen. [illegible] K[illegible] zwei Mitteladern zeigen . . . wodurch das Mittelfeld in ein äusseres und ein inneres Mittelfeld getheilt wird. GOLDENBERG, Palaeontogr. IV, 20–21.

[4] Bei den Blatten der Jetzwelt munden die Adern dieses Hinterfeldes [anal field] theilweise in die Begrenzungsader [anal furrow] desselben, während bei den Lias- und Kohlenblatten sämmtliche Adern dieses Feldes in den Nahtrand [inner margin] auslaufen. GOLDENBERG, Palaeontogr. IV, 20.

so that the area of this vein generally occupies half the breadth of the wing, and together with the branches of the mediastinal vein, half of the whole area of the wing; it emits four or five branches, some of which fork, occasionally twice, and all of which run parallel or very nearly parallel to the outer branch of the mediastinal vein; to gain the apex and to keep this parallelism the terminal part of the scapular vein curves gently upward. The externomedian vein seldom forks before the middle of the wing and rarely occupies much space, generally branching but three times at the most, although one or more of these branches may have secondary forks; generally these branches are so straight that it is difficult to say whether they are superior or inferior to the main vein, but they appear to be indifferently one or the other. The internomedian and anal veins divide between them very equally the inner margin of the wing, the anal furrow being distinct, generally curved considerably and, from the great breadth of the wing, having its general course very oblique; the internomedian vein generally has but three or four branches, but several of these usually fork close to the base, the branches redividing, so that rarely less than nine or ten branches of this vein strike the margin, the first offshoot of the penultimate branch often having several inferior veinlets; the vein begins to branch at nearly the same point as the scapular vein, and occupies a subtriangular area with its spreading branches. The branches of the anal vein are in general more longitudinal than those of the internomedian vein, are nearly parallel, often forked and rather regular and abundant, but in one species are irregular and connected by cross branches.

The wings are peculiar for their unusual breadth at base and, so far as known, their tapering apex, produced mostly by the costal curve; the greatest breadth lies before the middle of the wing, and their length is hardly more than double their width, in which particular they differ greatly from Lithomylacris. They have a form common in recent Blattariae, such as Nyctibora, strongly tapering posteriorly, with convex anterior and posterior margins.

This genus differs principally from Lithomylacris by the form of the wing and by the obliquity of the anal furrow of the same; and from Necymylacris by the much greater breadth and longitudinal extent of the areas covered by the mediastinal and scapular veins, accompanied by a corresponding diminution of the extent of the externomedian area. The species are all of a rather small or moderate size and are found only in the new world.

The only fragment apart from front wings which has been discovered is a pronotal shield, presumably belonging to one of these species. It is shaped much as in the modern Periplaneta.

Mylacris bretonense. Pl. 5, fig. 1.

Blattina bretonensis Scudd., Can. Nat., VII. 271–72, fig. 1. Figured also in Dawson's Acadian Geology, Suppl. to 2d ed., p. 55, fig. 5.

The front wing has a pretty regularly tapering ovate outline, with a slightly produced but rounded tip; the costal margin is apparently regularly and considerably convex, especially near the base, and at least the middle third of the inner margin is straight, while the apical third of the wing tapers about equally from both sides. The veins appear to originate from a point scarcely above the middle line of the wing, and together to be directed considerably upward at base, following the strongly arcuate basal curve of the costal margin nearly across the basal fifth of the wing. The mediastinal area is exceptionally small for this genus, even if we consider, as is probable, a marginal half to be destroyed; the veins in the fragment of it are somewhat obscure, consisting of only two or three parallel to each other, the lower or inner forking twice near the base and terminating a little before the middle of the wing. The scapular vein suddenly bends at the end of the basal fifth of the wing and runs closely parallel to the costal margin for a distance equal to about half the length of the wing, and then curves somewhat rapidly to a longitudinal direction, running down the middle line of the wing and terminating at its tip; its first vein, which like most of the others is deeply and simply forked, continues the direction of the basal part of the stem; the last is a shoot which parts from the main stem at about the middle of its longitudinal course; the intermediate ones, to the number of five, part at equal distances from one another in the oblique portion of the main stem, and are straight and parallel to the direction of the basal branch. The externomedian vein parts abruptly from the scapular vein shortly before the end of its basal course and runs subparallel to it, diverging gently from it in the apical half of the wing and emitting, at regular and distant intervals, three or four superior, gently arcuate, simple or forked longitudinal branches, commencing at a little before the middle of the wing, the first branch approaching the scapular vein and then continuing beside it; the area occupies only a narrow space at the extremity of the inner margin. The internomedian vein parts from the scapular just before the externomedian and in a nearly similar way; it runs nearly parallel to the latter, but with a very straight course, to about the middle of the apical half of the wing; normally it probably emits four or five simple or forked branches not quite so closely crowded as those of the two preceding areas; but in the specimen examined several of them spring from an off-shoot of the second branch which runs parallel to the main stem, the latter forking once at its tip; there is also a strongly arcuate vein, close and parallel to the anal furrow, which seems to be a basal branch of this vein parting from it while still amalgamated with the preceding veins. The anal furrow is deeply impressed, strongly arcuate, roundly bent near the base, its apical half nearly straight, and strikes the inner margin a little before the end of the basal third of the wing; owing to the basal curve the anal area is nearly as broad as long, and is filled with six or seven nearly straight veins of varying obliquity, some of them branched and the branches uniting irregularly with the neighboring branches in a very peculiar manner, somewhat, apparently, as in *Bl. mantidioides*.

The fore wing only is preserved and is of a rather small size, being only 16.35 mm. long and 7.2 mm. broad, or the breadth to the length as 1 : 2.3; all the veins and their branches (excepting of course the anal furrow) are very delicate and the branches generally rather closely crowded; the surface appears to have been smooth as the interspaces are wholly unbroken by any cross nervules. The wing is nearly complete, but the margin is rather ragged and a considerable portion of the edge of the costal border appears to be gone.

From the comparatively small extent of the mediastinal area and the nearly parallel veins therein this species cannot be confounded with any other form of Mylacris.

The specimen occurred on dark grey shale, associated with ferns and leaves of *Sphenophyllum Schlotheimii*, and was found with the following species in the productive coal-measures (or middle coal-formation) of Sydney, Cape Breton, by Mr. Richard Brown, F. G. S., and communicated to me by Principal Dawson, to whose kindness I owe many similar favors.

Mylacris Heeri. Pl. 5, fig. 11.

Blattina Heeri Scudd., Can. Nat., VII, 272, fig. 2. Figured also in Dawson's Acadian Geology, Suppl. to 2d ed., p. 55, fig. 6.

Fore wing. The tip of the only specimen known is broken so that the exact form cannot be stated, but the wing was probably a little more than twice as long as broad; the costal margin is regularly and moderately convex, perhaps a little flattened in the middle; the base of the inner margin is nearly straight. The veins originate from a point a very little below the middle of the wing, and having scarcely the least upward curve at base are nearly straight. The mediastinal area is very large, regularly triangular, with only a few distant straight very gently diverging veins; in the specimen before me there are four veins, of which the lowest is forked almost at the base and the second in the middle; almost the entire costal edge preserved is covered by this area and it probably covered two thirds of the wing along this border, and occupied fully half the breadth of the wing at base. The scapular vein is very gently sinuous, being curved slightly downward close to the base and upward toward the tip, the intervening portion being straight and passing exactly down the middle line of the wing; the branches, four in number, are straight, equidistant, parallel to the nearer mediastinal veins, only the basal one (which originates very near the base) being forked and that close to the tip; the vein itself, judging from its apical direction, terminates just before the tip, leaving at the margin a very narrow field for this area. The externomedian vein is straight and forks probably at the middle of the wing; how many times it forks is uncertain, two branches only being present in the fragment; the area must occupy the whole of the apex of the wing. The internomedian vein is also remarkably straight, having only the slightest curve at the extreme base and probably terminating just as far before the tip as the scapular vein; it emits, in the fragment preserved, three rather closely approximated branches, the outer more longitudinal than the others and forked; from the course of the upper branch of this fork (not represented as sufficiently longitudinal in the plate) and from the absence of other primary branches from the apical portion of the main stem which is preserved, it is probable that this secondary branch runs parallel to the main stem and that the outer branches are emitted from it, as in the preceding species. In keeping with the straightness of the other veins, the anal furrow is exceptionally straight; it is deeply impressed only over its basal half and is very gently and equally curved throughout, terminating probably at about the middle of the posterior border; the anal veins are five or six in number, most of them forked near the middle, the innermost compound, and the outer more closely approximated than the others; all of them are straight beyond a frequently curved base.

The species is a tolerably large one, the fragment of the wing being 21 mm. long (its probable entire length about 25–26 mm.) and its breadth 11.8 mm., or the breadth to the length as 1 : 2.1. The veins and their branches are rather distinctly impressed, somewhat distant and regular; the interspaces are transversely and very faintly wrinkled, rather than provided with cross-nervules; the surface is nevertheless pretty smooth; the costal margin is very delicately marginate. The tip of the wing is broken off, so that from a fourth to a fifth is gone, but the fracture extends much further down the inner margin, extending even onto the anal area.

The course of the anal furrow separates this species from all others of the genus. In the structure of the internomedian vein, but in hardly any other special feature, it is allied to *Myl. bretonense*. In the general distribution of nearly all the veins it is very nearly related to *Myl. pennsylvanicum*, a slightly larger or at any rate a broader species; indeed these two species are more closely related than any other two American forms; but the slight curvature and consequently great length of the anal furrow of this species forbid their being considered the same, and this differs also from the other in the less crowded neuration of all parts of the wing, in the less sinuous course of the scapular vein, and in many other minor points.

The single specimen occurred on dark grey shale, associated with ferns and leaves of *Sphenophyllum Schlotheimii*, and was found, with the preceding species, in the productive coal measures (or middle coal formation) of Sydney, Cape Breton, by Mr. Richard Brown, F. G. S., and communicated to me by Principal Dawson.

Mylacris pennsylvanicum nov. sp. Pl. 5, figs. 13, 14.

Fore wing. Only the basal half of the wing is preserved, with none of the inner margin, so that it is impossible to determine the form of the wing; the course of the veins however would seem to indicate a shorter and stouter, as it certainly is a broader wing than in *Myl. Heeri*. The outline as given in fig. 14 probably makes the wing a little too long. The costal margin is regularly and considerably convex, more so than in *Myl. Heeri*. The veins originate from the middle of the wing or slightly below it, and curve a little at the base. The mediastinal area has a basal width of half the wing and, separated from the scapular by a scarcely curved line, strikes the costal margin close to the limit of the fragment, and probably somewhat, perhaps considerably, past the middle of the wing; the extreme base is covered in the specimen by a foreign object, but four veins appear beyond it,[1] the two middle ones simple, the others deeply forked, all tolerably close, scarcely divergent, oblique and very gently arcuate; toward the humeral angle there are no veins and the edge of the wing at this point is very narrowly and delicately marginate. The scapular vein is gently and broadly sinuous throughout and probably terminates before the apex of the wing, to judge from its apical curve; it runs very closely parallel to the costal margin through most of its course, and down very nearly the middle line of the wing, perhaps nearer the costal than the inner margin; it commences to divide very near the base and emits five branches, all but the first of which are simple and all are subparallel to the course of the outer mediastinal veins; the basal branch is doubly forked and renders this portion of the area a little more crowded. The externomedian vein is arcuate until it divides, before the middle of the wing certainly, and some distance before the extremity of the fragment; it forks only once however in the part preserved, two parallel veins running longitudinally to the edge, equidistant from each other and the veins on either side. The internomedian vein runs in a broadly sinuous course parallel to the preceding vein, and although much obscured upon the specimen, at least one and perhaps two branches can be seen to be emitted before the division of the externomedian vein. The anal furrow is strongly impressed upon its basal half, less so but still distinctly upon the apical half, appears to be composed of a pair of fine grooves closely approximated, and is regularly and not very strongly arcuate, terminating on the inner border at some distance before the

[1] In both the figures on our plate the vein nearest the humeral angle should be erased; it does not exist.

end of the mediastinal area, and about opposite the origin of the last scapular branch; the anal veins are numerous and crowded, the first deeply forked and basally distant from the furrow, the others simple and all slightly arcuate and subparallel to the basal half of the furrow.

The single known fragment represents a tolerably large species, the breadth of the wing being 13.5 mm., while its length may be estimated as anywhere from 24 to 30 mm., the actual length of the fragment being 19 mm. and the breadth to the length about as 1 : 2. It is the under surface of a left wing which is exposed, in which all the veins and branches of the costal half (namely those of the mediastinal and scapular areas) are prominent, while all the others are very obscure, and as the obscurity affects to some degree the anal furrow, it is probably entirely due to the preservation; by favorable light and on careful examination, slight indications of transverse wrinklings may be seen in the scapular area, but there could have been no regular nor definite reticulation.

The species, which is peculiar for its breadth and the slight tendency of its branches to subdivide, appears at first glance to have considerable resemblance to *Myl. Heeri*; but it is certainly distinct from that by the stronger curvature of the anal furrow and consequent abbreviation of the anal area; it also differs by the sinuosity of the scapular vein, the more arcuate line of separation between the mediastinal and scapular areas and the more crowded branches of at least these areas. From *Myl. anthracophilum* it may be distinguished by the lack of the strong deflection of the base of the principal veins, by its less crowded venation, simpler branches and by the direction of the branching portion of the scapular vein, which is parallel to the border in this species, but converges toward it in *Myl. anthracophilum*.

A single specimen, marked No. 284 by the discoverer, Mr. I. F. Mansfield, was found at Cannelton, Beaver Co., Penn., in dark sandy shale immediately under a vein of cannel coal known as the vein C of Professor Lesley. It is partly covered by a leaflet of *Sphenophyllum Schlotheimii*. Lower coal measures of Penn.

Mylacris anthracophilum. Pl. 5, figs. 6-8.

Mylacris anthracophila Scudd., in Worth. Geol. Surv. Ill., III, 568-70, figs. 5, 6.

Fore wing. The wing is very broad at the base and tapers almost from the base by the slope of the costal margin, which is strongly and regularly arcuate, while the inner margin is nearly straight, bringing the rounded but rather produced apex in the lower longitudinal half of the wing; the extreme apex is broken. The veins originate below the middle of the base and curve strongly upward before assuming a more longitudinal direction, when all are subparallel to the costal margin. The limitation between the mediastinal and scapular areas is strongly arcuate basally, straight apically, and the mediastinal vein terminates at the end of the apical three-fifths of the wing; the mediastinal branches, three or four in number, most of them forked, are straight or very gently arcuate, and radiate from a common point near the middle of the base of the wing, some of them plainly emitted from the principal vein just beyond the base, and one from the same at a considerable distance from the base. The scapular vein is strongly arcuate at the base, but, next the last branching of the mediastinal vein, takes a nearly straight longitudinal direction, subparallel to but slightly converging toward the costal margin, and terminates near or at the tip of the wing but below the middle line of the same; it emits five equidistant almost equal longitudinal branches, each of which forks at or somewhat beyond its middle and at similar distances from the costal margin; the mediastinal and scapular branches accordingly change their direction in the most gradual way from nearly transverse to longitudinal, and the mediastinal and scapular areas together occupy nearly one-half the width of the wing. The externomedian vein, strongly arcuate, like the preceding, at the base, begins to divide as soon as that, and beyond this is straight, terminating at a short distance before the tip of the wing: its first branch passes down the middle of the wing and dies out a little beyond the middle; its three other branches, which like the first are superior, are emitted further out in the apical half of the wing and are each simply forked before their middle; the upper fork of the first of these approximates very closely to the scapular vein, leaving no passage for the basal branch. Beyond the base the internomedian vein is also straight and emits four equidistant branches, the first (at near the origin of the basal branches of the preceding veins) being doubly, the others, excepting the apical, simply forked. The anal furrow is deeply impressed, very regularly and rather gently arcuate, terminating a little before the middle of the wing; the anal veins are numerous, gently sinuous and mostly simple, the upper ones deeply forked and more distant.

The species is a little above the medium size, the length of the fragment preserved 28.5 mm., being scarcely shorter than the real length of the wing; its greatest breadth, at the end of the basal fifth, 13.5 mm, or the breadth to the length as 1 : 2.1. The specimen is very nearly perfect, and represents the upper surface of a right wing; the anal area is swollen; the veins of the wing are prominent, and the interspaces are rather regularly divided by inconspicuous straight cross-lines.

The species is remarkable in this genus for the form of the wing, which has its tip noticeably within the middle line of the wing and somewhat produced. In this it differs decidedly both from *Myl. bretonense* and *Myl. Mansfieldi*. It agrees better in this point with *Myl. Heeri*, but the crowded neuration of *Myl. anthracophilum* with the strong deflection of the base of the veins distinguish it at once from that species. There is only left *Myl. pennsylvanicum* with which to compare it; and although the apex of that species is so far lost as to render it very imperfect, we may be sure from the sinuosity and apical curve of the scapular vein that the apex of the wing is not within the middle line; it is further distinguished from *Myl. pennsylvanicum* by its tapering form and the very strong basal deflection of the veins; so that this species is abundantly distinct from all the others. Besides the front wing a pronotal shield has been found. At least it probably belongs to this species, as the size agrees and both came from the same locality and were collected at the same time. It is of nearly the same form as in *Periplaneta americana* (Linn.), broadest in the middle of the posterior half where it is roundly angulate, and in advance of which it tapers very rapidly to a convex front, hardly angulate laterally; posterior border broadly and strongly convex; its immediate edge narrowly and very slightly raised; the whole pronotum is a little convex, and the surface is nearly smooth, with a few minute, transverse and longitudinal lines; its greatest breadth is 16 mm.; its anterior breadth 9.5 mm.; length 12 mm.

The specimens above described were found by Mr. A. H. Worthen, at Colchester, McDonough Co., Illinois, in the roof shales of coal No. 2 of the Illinois Survey, and by him communicated to me. Lower coal measures of Illinois.

Mylacris Mansfieldii nov. sp. Pl. 5, fig. 15.

Fore wing. The base of the wing is broken, but the part preserved shows an oval outline, with similarly arcuate costal and inner margins and a somewhat pointed tip, the extremity of which is rounded; the tapering of the wing includes all the apical half. The mediastinal area is very large, occupying fully one-half the breadth of the wing at the base and covering about two-thirds of the costal margin; the veins of its outer half (the base is broken in the specimen) are very long, very slightly arcuate, slightly radiate but subparallel, simple or deeply forked and closely crowded, and the limitation of the area next the scapular vein is straight. The scapular vein runs nearly parallel to the costal margin, at least in the middle of its course, but in the apical third becomes longitudinal, passing down the wing scarcely above its middle line; it commences to divide near the base of the fragment, and probably a little before the end of the basal third of the wing, and emits five branches at unequal distances apart, one or two of which are singly or doubly forked, and all run parallel to the outer mediastinal branches; the vein terminates at the tip of the wing and so the area occupies on the margin the apical third of the costal border. The externomedian vein has a slightly arcuate course, which, contrary to what is customary, runs subparallel to the inner margin and, commencing to divide a little before the middle of the wing, emits, near together, three inferior branches which are long, simple or forked and longitudinal, the basal ones more or less arcuate in the same sense as the main vein; as these branches are inferior, the interspace between the scapular and externomedian veins (running almost exactly down the middle of the wing) is marked by the divergence of the opposing nervules. The internomedian vein is broadly arcuate and terminates on the inner border considerably nearer the tip than the mediastinal vein; it emits three branches, the apical one compound, the others more or less deeply forked, so that this area is as crowded with veins as the others. The anal furrow is lightly impressed, scarcely arcuate in its apical half, and terminates at the edge of the fragment, probably at about the end of the basal half of the wing.

The species is a tolerably large one, the largest of the genus, the fragment of the wing measuring 24 mm. in length and 13 mm. in breadth; probably the entire length was about 30 mm. and the breadth to the length as 1:2.3. The wing is a left one and the upper surface is exposed; the veins are lightly impressed throughout and uniformly and rather closely crowded; the surface is nearly smooth, but with care a delicate wrinkling of obscure transverse lines can be made out.

The wing is peculiar for its tapering oval form and the inferior origin of the externomedian branches, which distinguishes it at once from every other species of this genus.

The single specimen found was sent to me by Mr. I. F. Mansfield and by him obtained at Cannelton, Beaver Co., Penn., in dark sandy shale immediately under the vein of cannel coal known as vein C of Professor Lesley. Lower coal measures of Pennsylvania.

Lithomylacris [illegible]

[illegible] wings consists of about five principal shoots, only [illegible] generally close to the base, all of them straight or [illegible] extending to variable distances along the costal margin. [illegible] the wing; the point toward which these branches [illegible] the costal margin of the wings; this with the [illegible] gives the mediastinal area an unusual extent for Myla-[illegible]. [illegible] curved before branching, but beyond its first [illegible] the outer portion scarcely curving, and runs down [illegible] that the mediastinal and scapular areas together [illegible] wings; it emits four or five branches, more or less closely approxi-[illegible] and all run subparallel to, but rather [illegible] branches of the mediastinal vein. The externomedian area [illegible] occupying the lower half of the narrow tip of the [illegible] the tip of the wing, and then but once or [illegible] the first branch sometimes forking. The interno-[illegible] nearly equally between them the inner margin of [illegible] and gently arched, and, from the [illegible] of the common point of origin for all the [illegible] the species differing in this respect some-[illegible] Mylacris; the internomedian vein has only two or [illegible] very long, and yet fork comparatively [illegible] its first branch somewhat before, opposite to, or [illegible] the origin of the first branch of the scapular vein. The branches [illegible] where they are parallel, rarely fork, and [illegible] the internomedian vein.

[illegible] and nearly parallel sides; the greatest [illegible] generally three times as long as broad, being [illegible] M[illegible]

[illegible] of this genus, which differs from Mylacris in the [illegible] and gentle curve of the anal furrow, [illegible] and also by the unusual sulcation of the [illegible] from Necymylacris it is readily separated by the very [illegible] areas. The species are all of rather [illegible] in America.

Lithomylacris angustum [illegible] Pl. [illegible] figs. 2, 3.

[illegible] the inner margin straight, the costal margin [illegible] the wing narrows from the middle, at first very slightly. [illegible] is broken in part, but was evidently well rounded [illegible] the wing probably not so slender as in the preceding [illegible] considerably below the middle of the wing. [illegible] outward, the upper ones curving very [illegible]. The mediastinal area is fully half the width of the wing at the base, and occupies very nearly two-thirds of the costal margin, its [illegible] next the scapular area being almost straight, a slight sinuosity being scarcely [illegible]; the gently radiating veins of this area are six or seven in number, those next the [illegible] simple and distant, the two outer somewhat sinuous, simply or doubly forked [illegible]. The scapular vein curves gently upward at the base until it has nearly reached the middle of the wing, next passes down the middle or slightly below it, subparallel to the costal margin, and then curves gently upward again, its entire course being very broadly and gently sinuous, terminating at the apex; it begins to divide at the end of the basal fifth of the wing, almost before it has lost its upward curve, and emits half a dozen oblique branches, the first pair near together, the rest at subequidistant intervals; the second and third are forked near the middle, one of the branches of the former again at the tip, but the others are simple; they become increasingly longitudinal toward the tip, but only to a very slight degree, continuing the decreasing radiation of the mediastinal veins; together these two areas occupy more than half of the wing. The externomedian vein runs in a straight course nearly to the middle of the wing, scarcely turned downward from a longitudinal direction; here it forks, the upper branch again forking near the tip, the lower at less than half way to the border, each of the latter forks again dividing, the upper before, the lower beyond its middle; all follow a longitudinal direction and occupy upon the margin only the lower half of the narrow apex of the wing. The internomedian vein is remarkably straight throughout and is indeed the only palaeozoic cockroach known in which it is straight; it terminates just before the tip of the wing, commences to divide almost as soon as the scapular vein, and emits, long before the middle of the wing and at regular and short intervals, three straight veins, the first simple, the others forked in the middle, all having a constantly lessening obliquity, so that the outermost fork is parallel to the main vein; besides these the main vein emits another slight longitudinal branch close to the apex, and the whole area occupies about one-half of the inner border of the wing. The anal furrow is very deeply and sharply impressed and scarcely at all arcuate, running in nearly a straight line to a little before the middle of the wing; the anal veins, four in number, one of the middle ones forked, are straight, equidistant and parallel to the furrow.

The wing is a little above the medium size, [illegible] mm. long, and yet only [illegible] mm. broad, or the breadth to the length as 1 to a little more than 3. It is nearly perfect, being only a little fragmentary about the base and the lower portion of the tip. It is a left wing, of which the under surface is exposed, showing the veins and anal furrow as ridges; the anal furrow is remarkably prominent, and most of the veins are also very prominent; this is especially true in the veins of the scapular and externomedian areas; the internomedian vein itself, as far as its apical fork, is also almost equally prominent, but all its branches are mere lines upon a flat field; while in the areas covered by the prominent veins the interspaces are roundly sulcate, giving additional prominence to the veins; in the mediastinal area, however, where the veins are somewhat prominent, the interspaces are not sulcate, and the anal area, which must as a whole be broadly vaulted or tumid as seen from the upper surface, partakes of the nature of the internomedian area; the surface itself of the whole wing is smooth, no trace of cross venation being discernible. From its deflection in the reversed specimen, it would seem that the whole costal edge was slightly margined.

This species, like the next, is peculiar for the division of the internomedian vein, which, excepting for a small apical fork, emits all its branches near the base; in shape it closely resembles that species, even to the flatness of the internomedian area; but it differs from it in its greater length, the greater frequency of the branches, and their much more abundant forking, especially in the externomedian vein, which also divides much nearer the base in this species than in *Lith. pittstonianum.* The shape of the wing and the closer venation at once separates this species from *Lith. sulcatum.*

The single specimen was found with the following species by Mr. R. D. Lacoe, at Port Griffith switch-back, near Pittston, Penn., in the roof shales of the E seam of coal of the Second Pennsylvania Survey, and by him forwarded to me for examination. Upper coal measures of Pennsylvania.

Lithomylacris pittstonianum nov. sp. Pl. 5, figs. 4, 10.

Fore wing. The single specimen known is very imperfect, the base, anal area, and a large part of the tip being lost, and the remainder badly fractured; it is evident, however, that the wing is very long and slender, with a gently and regularly arcuate costal margin; probably the wing is nearly equal, tapering very gently on the apical half. The veins must originate below the middle of the wing, and are nearly straight. The mediastinal area, which is more than half the width of the wing at the base, terminates at the middle of the costal margin, and is separated from the scapular area by a straight border, the veins, six or seven in number, being straight, gently divergent, and simple or rarely connected close to the base. The scapular vein runs parallel to the costal margin in the basal half of the wing, gradually approaches it in the apical half, and terminates probably a little before the tip; it emits five simple, straight branches, which divaricate very slightly in continuation of the divergence of the mediastinal veins, which they entirely resemble; the mediastinal and scapular areas together occupy just about one half of the wing. The externomedian runs parallel to the scapular vein, divides a little beyond the middle of the wing, and emits about four inferior, slightly arcuate branches, which are simple (unless the first be apically forked), and together probably occupy the entire apical margin of the wing. The internomedian vein is very gently arcuate, and must terminate just before the tip of the wing; it emits, wholly in the basal third of the wing, three simple or simply forked branches which are very longitudinal. The anal furrow is distinctly but not heavily impressed, very gently arcuate, and must terminate at about the end of the basal third of the wing; but such is the slenderness of the wing and the low origin of the principal veins, that the anal area must be several times longer than broad.

The wing is of moderate size, the fragment measuring 22.5 mm. in length and 8.5 mm. in breadth; probably the entire length of the wing is 26 mm., or the breadth to the length as 1 : 3; it is a left wing with the upper surface exposed; the veins are all very distinctly impressed, excepting those of the internomedian area, which are obscure; the interspaces between the veins are vaulted also, so as to add to the impression of the veins themselves; but otherwise it is smooth excepting in the flatter internomedian area, where a delicate and crowded cross-veining is faintly marked; the basal third of the costal edge is gently margined.

With the preceding species, this insect is peculiar for the basal attachment of the internomedian branches. In its shape it resembles only *Lith. sulcatum* in this genus; from this it differs in the simplicity of the branches, which are very rarely furcate; consequently the venation is much more open, and in this respect it approaches *Lith. simplex*, with which, from its shape, it could not possibly be confounded.

The single specimen found was obtained by Mr. R. D. Lacoe with the preceding at Port Griffith switch-back, near Pittston, Penn., in the roof shales of the E seam of coal (of Prof. Lesley's table). Upper coal measures of Pennsylvania.

Lithomylacris simplex nov. sp. Pl. 5, fig. 5.

Fore wing. The wing is long oval, tapering beyond the basal third, but very gradually, the costal margin much arched next the base, the humeral lobe being large and well rounded; but along the most of its course the costal margin is very gently convex, almost straight in the middle; inner margin gently convex, the tip tapering but well rounded; the wing is much broader than in the other species of the genus. The veins originate somewhat below the middle of the wing, and curve upward very slowly with a broad arcuation. Mediastinal area occupying more than half the base of the wing, and on the costal margin almost the entire extent of the wing, terminating only a little before the tip; it is separated from the scapular area by a very gently and broadly arcuate limitation, and is filled with very few veins (only three in the specimen seen), each of which forks once near or at its base; all are divergent and gently and broadly arcuate, the outer the least so, and all fail to reach the margin. The scapular vein is very broadly arcuate, running down the middle of the wing parallel to the costal margin, and, finally longitudinal, terminates just beyond (*i.e.*, below) the extreme tip of the wing; it commences to divide while still arcuate, just beyond the basal fourth of the wing, and emits at subequal distances apart four simple, gently arcuate branches, having a similar direction to the outer mediastinal veins, but if anything less longitudinal. The externomedian vein, arcuate as far as the division of the scapular, is straight beyond this, parallel to and rather distant from the same, forking simply at the end of the middle third of the wing, and occupying only an inconsiderable space on the border just below the tip of the wing. The internomedian vein is similar to the preceding at the base, but becomes straight a little sooner and continues straight to the tip, terminating about as far from the apex as the mediastinal vein; it emits a very short branch close to the tip, another a little beyond the middle of the wing, and two others, which must have their origin much nearer the base, as in the other members of the genus; only the apical portion of the outer of them, however, can be traced on the specimen. The anal furrow is distinct but not deeply impressed, is very regularly and rather gently arcuate, and terminates just beyond the middle of the wing, affording a very large anal area.

The wing is of medium size, measuring probably 24 mm. in length (the fragment is 22.5 mm. long) and 10 mm. in breadth at the middle, which is probably not quite so broad as the middle of the basal half of the wing; or the breadth is to the length as 1 : 2.4. It is nearly perfect, a small portion of the tip only being lost, together with the whole anal area; it represents a left wing seen from the under surface, the veins being in relief; the veins are prominent, but not remarkably so, and the anal furrow no more prominent than they, if it is as prominent; as in the preceding species, the branches of the internomedian vein are not elevated; indeed they cannot all be traced in the somewhat worn specimen, and the vein itself, as well as the externomedian, partakes in part of the obscurity; this region also is that, while the interspaces of the scapular and mediastinal areas, especially of the former, are broadly sulcate (*i. e.*, arched on upper surface) but much less so than in the other species of the genus; the surface seems to be completely smooth, is of a carbonaceous black in the specimen, distinguishing it strikingly from the clay-colored matrix. The extreme edge of the entire humeral lobe is marginate as far as the mediastinal veins.

The wing is peculiar for the very large proportion which the mediastinal and anal areas occupy to the rest of the wing, and for the extreme simplicity of the neuration, in which there is not a single forked branch outside the mediastinal area; the veins are very distant and the species is at once distinguished from the others of the genus by the much stouter shape of the wing, which is much less, while they are much more than three times as long as broad.

The single specimen discovered was obtained by Mr. Wm. Gurley, from the coal measures of Illinois, about six miles from Danville, and sent me by him for study. Lower coal measures of Illinois.

Necymylacris nov. gen. (*νέκυς, μυλακρίς.*)

The mediastinal vein of the upper wing differs from the same vein in the other members of this group, to judge at least from the most perfect specimen, in emitting from the outermost vein several branches at infrequent intervals, even to a long distance from the base; these branches may themselves be compound, so that a certain resemblance or approximation to Blattinariae may be seen; but, in addition to these, there are the usual radiating veins next the humeral lobe; in the typical species, the only perfect specimen of the genus known, the last vein terminates in the middle of the apical half of the wing, but in the other it appears to be much shorter. The scapular vein, curved or bent before branching (which it does near the end of the basal third of the wing) thereafter runs in a straight or sinuous course to a little before the tip of the wing, emitting three or four veins which may be multiple-branched or perfectly simple. The externomedian vein is forked a little before the middle of the wing, and emits a number of forking branches, which, while they are longitudinal in direction, are superior, so that the equal interspace between the externomedian and internomedian veins is marked by oppositely diverging branches; the externomedian area occupies the entire or almost the entire apical border of the wing, so that it is of a narrow wedge-shaped form. The internomedian area is apparently more extensive than the anal, the anal furrow terminating on the inner margin nearly opposite the termination of the mediastinal area and having a rather oblique curving course; the internomedian vein emits five to ten branches, generally simple, occasionally forked at the base, and in one of the species itself forks longitudinally not far beyond the middle, the upper fork dividing near the tip and the lower emitting the apical branches; these all run in a slightly curved course more oblique than the anal furrow. The branches of the anal vein are numerous, run more longitudinally, are more closely crowded toward the anal angle and fork feebly, excepting the upper one which, though considerably curved, is well separated from the anal furrow and emits several inferior branches.

Besides upper wings, the slight fragment of a part of one of the lower wings has in one instance been found, in which the veins of the apical portion are thickly crowded, straight and parallel, and fork feebly toward their tip.

The genus differs from the two preceding by the smaller extent, both in breadth and length, of the combined mediastinal and scapular areas; from both also, but particularly from Lithomylacris, in the great extent of the externomedian area. The species are of large size, including the largest American forms, and are unknown to Europe.

Necymylacris lacoanum nov. sp. Pl. 5, fig. 12.

Fore wing. The form is indeterminable from the only fragment known, although it is probably proportionally shorter than in *Nec. heros*; the veins are all strongly curved at the base. The mediastinal area is less extensive than in the other species of the genus, and resembles the other genera of Mylacridae to a greater extent in a more radiate disposition of the veins, at least four in number, of which the last has at least three rather distant and apparently simple branches, the outermost originating at some distance beyond the first division of the scapular and internomedian veins; probably the area does not extend beyond the middle of the wing. The scapular vein has a rather strongly sinuous curve and at least three straight and simple branches, of which the first, probably arising in the middle of the basal half of the wing, is in direct continuation of the basal portion of the vein, and thus separates the scapular from the mediastinal area by a straight line; the branches are parallel to the outer of the mediastinal veins, and the area, which is certainly broad, probably more than a third of the breadth of the wing, extends no doubt nearly to the tip of the wing. The externomedian vein beyond its basal curve is straight, and first divides beyond the last (preserved) branch of the scapular vein, or, probably, shortly before the middle of the wing; it emits at least two superior branches, the simple bases only of which are preserved in the specimen, but, from the divergence of these, the area probably occupies the entire apex of the wing. The internomedian vein is regularly and very strongly arcuate, probably terminating at some distance before the tip, and emits four equidistant, well-separated branches, one of which is deeply forked, the others simple, all straight or gently arcuate and very long, the area occupying apparently more than half of the wing. The anal furrow is scarcely more distinct than one of the veins, and is nearly as straight as they, appearing to originate from the internomedian vein near the base of the wing, and terminating probably a little before the middle of the wing; the anal veins are numerous, especially toward the basal angle, gently arcuate, simple or forked, the outer one very much curved, distant from the others, and compound.

The wing is of medium size, the largest fragment measuring about 13 mm. long, and the breadth of the two fragments when united nearly 12 mm.; probably the entire length of the wing was about 25 mm., and the breadth to the length as 1 : 2. It is a left wing, of which the upper surface is exposed, but is very fragmentary and shattered, no part of the border, unless in the unimportant anal area, being preserved; probably nearly half of the apex is gone, as well as a slight part of the base; the veins are delicately impressed, but distinct, excepting toward the costal border, and the surface flat, and, at least in the internomedian and anal areas, rather distinctly marked with very frequent transverse wrinkles.

Hind wing. Protruding from beneath the front wing is a small fragment of a hind wing, apparently the apical lower portion of that of the opposite side of the body; all that can be made out are about a dozen straight equidistant parallel veins, about half of them (mostly those nearer the apex of the wing) forking simply; their direction, as they lie on the stone, is parallel to that of the scapular veins of the front wing. In distinction from the veins of the front wing, these are slightly elevated, and the basal half of the fragment has a glistening surface, while that of the apical half is dead and shows exceedingly faint traces of transverse wrinkling like the cross neuration of the front wing. If, as the direction of the veins leads us to suppose, the wing is that of the opposite side of the body, and has its natural position as closed, the hind wing of this insect must have been very broad, broader indeed than the remains of any other palaeozoic cockroaches would lead us to presume in them.

Notwithstanding the fragmentary nature of the fossil, it is plainly distinct from any other known form. The structure of the mediastinal vein, although approximating to a certain degree that of the Blattinariae, plainly shows it to belong to the Mylacridae, and is indeed not very different from the same vein in *Lithom. angustum*, while the very arcuate form of the internomedian vein, combined with the great breadth of this area, separate it at once from all the species of Mylacridae mentioned here. Its generic affinities with Necymylacris are doubtful, and the material is insufficient for accurate determination of all the points which should be settled before reference to a distinct genus can be made, but it agrees with that genus to a certain extent in several points in which it differs from other Mylacridae, and especially in the mediastinal vein (although it is here very much simpler than in *Necym. heros*—as indeed is the whole neuration) and in the anal area, whose extent and the distribution of whose branches, and particularly the character of the compound branch next the anal furrow, is very similar.

The single specimen known (numbered 2009) was found by Mr. R. D. Lacoe in the lowest productive coal measures near Pittston, Penn., and by him sent me for examination.

Necymylacris heros nov. sp. Pl. 5, fig. 9.

Fore wing. The wing is long and slender, very long obovate, nearly equal; the costal margin is very gently convex, nearly straight along the middle, the inner margin even less convex, and the gently tapering apex rounded; the veins originate from near the middle of the base of the wing, and most of them curve upward a little for a short distance. The mediastinal vein is at first directed toward the middle of the basal half of the costal margin, but close to the base bends abruptly, and runs in nearly a direct line to the middle of the outer half of the costal margin, separated therefore by a straight line from the scapular area; next the humeral lobe, which is smooth, are two or three weak radiating veins which spring from the base of the principal vein; but most of the slowly narrowing mediastinal area is filled with scarcely radiating branches which spring unequivocally from the main vein beyond the base: there are three such principal branches, all originating in the basal third of the wing and compound, besides a simple apical branch near the tip; each of these compound branches, which are as nearly longitudinal as their position allows, emits, generally at some distance from its base, two or three outer simple or forked branches, so that the costal margin is filled with crowded veins. The scapular vein, gently arcuate until it divides, near the middle of the basal half of the wing, is thereafter straight, running down near the middle line of the wing and parallel to the costal margin; a little beyond the middle of the wing, however, it is deflected very slightly upward, the change being scarcely perceptible, and terminates on the apical margin just before the extreme apex; it emits four branches at unequal distances apart, all of them nearly longitudinal, the first being compound and dividing only at the middle of the wing,[1] the second doubly forked, and the third simply forked, both at a long distance from the origin, while the last, arising opposite the fork of the third, is simple. The externomedian vein is very broadly sinuous, being rather strongly arcuate at the base, then runs in a nearly straight line a little divergent from the costal margin, and, finally, in the apical third of the wing, becomes more longitudinal, and terminates just before the apical margin; it first divides opposite the second branch of the scapular vein, or at the end of the basal two-fifths of the wing, and emits at subequal intervals, the last a little beyond the middle third of the wing, four superior longitudinal branches, the first of which runs down the middle line of the wing, forks at a little before the end of the middle third of the wing, its upper fork again dividing; the second forks in the middle of its course, and the others are simple; all are closely crowded together, and occupy upon the border the lower part of the apical margin. The internomedian vein follows nearly the direction of the preceding, being strongly arcuate at the base, straight and considerably oblique in the second quarter of the wing, beyond this subparallel to the costal margin; at its change of direction, almost exactly in the middle of the wing, it emits a branch, which runs close to the main stem, and, excepting for an apical shoot, emits all the regular branches beyond its origin; including these secondary branches there are about ten simple slightly arcuate oblique veins, whose direction, especially that of the basal ones, is rather at variance, from their regular obliquity, with that of the branches of all the other veins; the basal branches are more closely approximated than the apical. The anal area being broadly tumid, the anal furrow is very deeply impressed, and is very strongly arcuate on the basal half, nearly straight on the apical half, and terminates a little before the middle of the wing; the anal vein next the furrow is straight and nearly longitudinal at base, curved gently downward beyond, and emits three or four arcuate distant branches; the other veins are very numerous and crowded, generally simple, nearly straight or arcuate, in an opposite sense to the first, and about as longitudinal as the mediastinal branches.

The wing is of extreme size, the largest of the American species, and only exceeded by *Anthracobl. spectabilis* of Europe; it is 48 mm. long and 18 mm. broad, or the breadth is to the length as 1 : 2.7; the specimen is almost absolutely perfect, and represents the under surface of a right wing; the principal veins and the main branches of the mediastinal, scapular, and externomedian areas before they fork are all distinctly pronounced; the forks of the same are delicately elevated, while the branches of the internomedian and anal areas are very delicately impressed,—all as seen on the under surface; the surface is flat, excepting where the principal veins are most pronounced, and here the interspaces are a little and broadly sulcate; all the interspaces, even in the anal area, but especially those which are sulcate, exhibit a minute tracery of nearly straight, very closely approximated, excessively delicate, scarcely impressed cross lines; those of the anal area are not sufficiently distinct in the plate.

This insect, from its extreme size alone, cannot possibly be confounded with any other American species, nor from the peculiar distribution of the mediastinal branches, in longitudinal bunches depending from the main vein, with any palaeozoic species. This peculi-

[1] The plate represents the first offshoot of this first branch as simple, but this is inaccurate, and was overlooked in revision; it forks near the tip or directly opposite the extremity of the first branch itself.

arity of the mediastinal vein is of special interest as showing a certain affinity to the Blattinariae, next which it is here placed; yet the distribution of the branches is nevertheless radiate, and the form of the area triangular and not band-shaped, according in this respect wholly with the Mylacridae. It should be taken as the type of Necymylacris, for the imperfection of the preceding species renders its alliance with this somewhat doubtful.

The single specimen, which I owe to the kindness of Mr. I. F. Mansfield, was obtained by him at Cannelton, Beaver Co., Penn., in a dark sandy shale immediately under the vein of cannel coal known as vein C of Professor Lesley. Lower coal measures of Pennsylvania.

Blattinariae.

In the second group into which the palaeozoic cockroaches may be divided, the mediastinal vein is not constructed like the anal vein, but like the other veins of the wing, being composed of a main vein which extends at least half way to, usually some way beyond, and sometimes quite to, the tip of the wing, emitting toward the costal border several branches which are usually subequal, equidistant and parallel, often forking once in some part of their course, the apical branches occasionally many-branched. The area covered by this vein and its branches is thus band-shaped, and terminates beyond the middle of the wing. The group occurs both in Europe and America, all of the European and somewhat less than half of the American species falling therein. The wings as a general rule are slenderer than those of most of the Mylacridae, the breadth being contained in the length on an average more than two and a half times.

Etoblattina (ἔτος, Blattina) nov. gen.

Blattina Auct (pars).

The mediastinal vein of the fore wings with its branches covers a rather narrow and not very extended area, being seldom more, seldom much less than one-fourth of the width of the wing, and generally terminating apically from a little more than one-half to a little less than two-thirds the distance toward the tip of the wing; in one or two instances, as particularly in *E. leptophlebica*, it extends a little more than two-thirds the distance; the area is usually of uniform width nearly to the tip, but it sometimes tapers throughout the entire apical half, and in *E. primaeva*, where the whole wing is very broad, it tapers with unusual rapidity and throughout the greater part of the wing; the principal vein emits from five to ten simple or forked, equidistant, oblique branches. The scapular vein generally terminates just before the tip of the wing, rarely at the tip itself, and occasionally is decidedly removed from the tip, though not to a great distance; it generally begins to fork a little before the middle of the wing, occasionally at it, and rather more frequently only one-third the distance from the base; and the branches usually take on the mode of distribution of those of the mediastinal vein, although the similarity is sometimes lost from the greater breadth of the area and the consequently greater length of the veins; in other instances, and particularly in those in which the early branching of this vein is correlated with more than an average length in the mediastinal area (as particularly in *E. venusta*), all similarity is lost, the division assuming more or less of an arborescent form, generally accompanied by frequent ramifications; as a general rule, however, more or less similarity exists between the two areas, and in some (as in *E. affinis*, *E. Dohrnii*) the resemblance is very great; the general course of the scapular vein is usually parallel to the costal margin, but without partaking of its generally slight convexity; beyond the immediate base of the wing therefore its course is nearly straight, sometimes with a gentle sinuosity; occasionally it is conspicuously sinuous, as in *E. lubachensis*, so that the greatest breadth of the scapular area is double that of the mediastinal; yet even here the general resemblance and trend of the branches of the two veins may be perfectly kept. The externomedian vein is of moderate importance, occupying always a portion, generally the whole, of the apex of the wing, generally commencing to branch not far from the first divarication of the scapular vein, but in this respect showing great variation; its branches are not numerous, occasionally reduced to two or three, and while longitudinal are yet always superior, so that the equal sinuously curving space between the externomedian and internomedian veins is always marked by divergent branches, very frequently arising exactly one opposite another. The internomedian vein originates near the middle of the wing in about half of the species (the first half of the species described below), somewhat above the middle in the other half; usually it is pretty straight beyond the arched base, and does not terminate so near the apex of the wing as does the scapular vein; but not infrequently it reaches as far as the scapular, or at any rate extends further than it otherwise would by curving outward near the tip, and thus reaching to a greater distance; there is therefore much difference in the rapidity with which this area narrows, being very rapid in some (as in *E. russoma*), very gradual in others (as in *E. Lesquereuxii*); its numerous veins are nearly straight; usually some of them are simple, and they have an obliquity about equal to those of the mediastinal vein, although of course in an opposite sense. The anal furrow is rather more lightly impressed than usual, arcuate and very oblique, generally terminating on the inner margin at about two-fifths the distance from the base; the veins of the anal area are usually simple or forked near the base, very frequent, subparallel and subequidistant, generally less arcuate than the anal furrow; in one species, *M. mantidioides*, they are very irregular.

Usually the upper wings are moderately slender, from a little less than two and a half to about two and three-quarter times as long as broad; but a few of the species have wings more than three times as long as broad, and the first two species differ from the others, not only in their unusual breadth, being only a little more than twice as long as broad, but also in other features, such as an unusual breadth (and in *E. lubachensis* an unusual length) of the mediastinal area, the narrowness of the externomedian area, and the extreme longitudinality of its branches; as, however, the form of the wing often appears to differ very considerably in species of the same genus in this group, there is not sufficient ground for the separation of these species from the others even as a section, and the more so as there are several other species, placed in the middle and at the other extremity of the genus, which have quite as broad wings. The general average is scarcely less than two and three-quarter times longer than broad, which is a trifle slenderer than the average of the whole tribe; and it is not a little curious that this is exactly the same proportion as holds in the genus next to this most prolific in species, Gerablattina.

Besides the front wings, which constitute most of the fragments of this genus preserved, there are two which show the hind wings also; one of these also has the thorax and abdomen, and a third the thorax. The hind wings appear to resemble the front wings closely, and not to be much larger, at least in one of the species; the thorax in both is similar, being subtriangular, tapering anteriorly, but with rounded sides and a rounded front. The abdomen in the single species where it occurs is extraordinarily slender, but apparently not cylindrical, as would at first appear from Goldenberg's illustration.

This genus differs from Archimylacris in the greater conformity of the mediastinal and scapular areas, the superior position of the branches of the externomedian vein, and the usually smaller extent of the scapular area; from Anthracoblattina, Gerablattina, and Hermatoblattina by the greater brevity of the mediastinal area and the correlated greater importance of the scapular area, as well as from the former by the superior position of the veins of the externomedian vein, and from the latter by the superior position of the branches of the scapular vein; from Progonoblattina it is readily separable by the unimportance of the externomedian area; Oryctoblattina differs from it in its excessive and peculiar development of the mediastinal area with its inferior branches, and by the excessive narrowness and length of the mediastinal area, as well indeed as by nearly every other feature in the wing; while Petrablattina, with the extraordinary development of its externomedian area, formed of longitudinally directed but yet superior branches, can be confounded with no other.

This genus is by far the most numerous in species of all the carboniferous types, a third of the species belonging to it; it is, however, almost exclusively European, for only two American species fall into it, one of these the first described from America; this is not a little curious, for the first known fossil cockroaches of the European coal measures also fall into this genus.

Etoblattina primaeva. Pl. 3, fig. 7.

Blattina primaeva Gold., Sitzungsb. math-nat. Cl. k. akad. Wiss. Wien, IX, 38; — Ib., Palaeontogr., IV, 22, taf. 3, fig. 4; — Ib., Foss. Ins. Saarbr., 6, taf. 1, fig. 4; — Ib., Jahresb. Gymn. Saarbr., 16; — Ib., Faun. saraep. foss., i, 16, taf. 2, fig. 13; — Ib., Faun. saraep. foss., ii, 19, 51; — Gieb., Ins. Vorw., 316; — Bronn, Leth. Geogn., 3 aufl., I, ii, 683, tab. 9[6], fig. 15[a]; — Heer, Viertelj. naturf. Gesellsch. Zürich, IX, 288; — Roem., Leth. geogn., tab. 47, fig. 18; — Gein., Geol. Steink. Deutschl., 149.

The front wing has a very regular ovate form, and is broader in proportion to its length than any other species of Blattina, being only twice as long as broad; beyond the expanding base, the front margin is very gently convex, and the hind border, at first nearly straight, tapers considerably in the apical half; the apex is very broadly rounded. The veins originate in the middle of the wing, but all curve at first upward, and where the middle ones assume a general longitudinal direction, the externomedian is considerably above the middle. The mediastinal vein passes with a very slightly sinuate course to a short distance beyond the middle of the front margin, emitting five or more simple or simply forked oblique branches. Beyond the basal curve, the main stems of the scapular, externo- and internomedian veins are longitudinal, nearly straight, and parallel; the first terminates in the upper and the last in the lower part of the tip, leaving only the central part of the apical margin in the possession of the externomedian vein. The scapular vein branches from its base and emits about five branches which are generally simply forked, and the last of which runs parallel to the extremity of the main stem. The externomedian is forked before the middle of the wing, its branches approximate and simply or doubly forked. The internomedian is scarcely arcuate, so that the area it covers narrows principally by the curvature of the margin; the vein emits four or five simply or doubly forked branches. The anal furrow is strongly arcuate on the basal, straight on the apical half, and terminates at the middle of the inner margin; the anal veins, eight or nine in number, are simple, parallel, and gently arcuate.

The single specimen of the wing known is blackish brown, perfect, excepting the extreme tip, the costal border distinctly marginate; the veins are distinctly pronounced, and the interspaces filled with delicate transverse veins, running from the veins and not meeting those of the opposite vein directly, but forming by their mode of union pentagonal, sometimes tetragonal, cells, which can be seen by the naked eye; those toward the apex of the wing being larger than the others. Length 39 mm., breadth 16 mm., or the breadth to the length as 1 : 2.4.

Goldenberg compared this species, which is of large size and one of the largest of the genus, with *Etobl. carbonaria*, but like the following species it is distinguished from other Blattinariae by the unusual breadth of the wing as compared with the length; and in this respect this species is the more remarkable, being only twice as long as broad; it is also readily distinguished from the following by the rapid narrowing of the mediastinal area, and by the brevity also of the same area.

Several specimens have been found in the Auerswald coal-seam in Gersweiler near Saarbrücken, Germany. Upper carboniferous.

Etoblattina labachensis. Pl. 3, fig. 5.

Blattina anaglyptica var. *labachensis* Gold., Vorw. Fauna Saarb., 16; — Ib., Faun. saraep. foss., i, 16, taf. 2, fig. 15; — Ib., Faun. saraep. foss., ii, 19.
Blattina labachensis Gold., Faun. saraep. foss., ii, 51.

The front wing has a regular obovate form, a very little more than twice as long as broad, the sides nearly parallel. Beyond the base, the costal border is broadly convex, the inner border very nearly straight, the apex very regularly and broadly rounded. The veins originate near the middle of the wing and have scarcely any basal curve. The mediastinal vein is very long and scarcely sinuate, terminating beyond the middle of the apical half of the costal border, which is unusual in this genus; it emits a large number of generally simple or forked oblique branches, and is itself so far from the border as to make the area very broad, about one-third the breadth of the wing in the middle. The limit between the scapular and externomedian areas cannot be certainly determined, either from Goldenberg's illustration or description; but is probably, almost certainly, as marked in our plate, where the latter is exceedingly narrow, as in the preceding species, occupying the extreme tip; both the principal stems are longitudinal and straight, and both probably fork near the middle of the wing, to judge from the incomplete course of those given in Goldenberg's illustration, and the branches sometimes fork singly, all the forks having a longitudinal direction, parallel and close to each other. The internomedian bends a little from the longitudinal course of the other veins toward the inner border, while passing over the anal area, but beyond that is nearly longitudinal, scarcely arcuate, terminating only a little below the tip of the wing, making the internomedian area, like the mediastinal, of unusual length for a species of this genus, by which it seems to have some affinity to Gerablattina; the area is also of unusual equality, occupying like the mediastinal about one-third the breadth of the wing; the main vein emits four or five branches, which may be simple or forked, but all have a nearly similar oblique direction. The anal furrow is, apparently, not especially distinct nor marked as an arcuate vein, but is nearly straight, terminating at the middle of the inner margin, and, like the other anal veins, following the direction of the internomedian veins; as no mention is made of the innermost region of the wing by Dr. Goldenberg, perhaps his illustration is faulty at this point, as indeed it would be rather anomalous; more probably the species would not be found to differ greatly in this respect from the preceding.

This species has a brownish colour, and a delicate reticulation, formed on the same general plan as that of the preceding species. It is of comparatively small size, being 20 mm. long and 9 mm. broad, or the breadth to the length as 1 : 2.2.

It was at first considered a variety of *Etobl. anaglyptica* by Goldenberg, but afterwards separated by him. He noticed at the outset the smaller size and broader shape, but it also differs decidedly in general shape, in the far smaller extent of both the scapular and internomedian areas, the length of the mediastinal area, and the widely different distribution of the veins in the internomedian area. The breadth of the wing separates the species at once from all the other species of Etoblattina excepting the preceding, and it is also peculiar, as remarked, for the great length of the mediastinal and internomedian areas, although in the last point other species of Etoblattina equal it. It differs from the preceding species by its much smaller size, its broader tip, and the small extent of the scapular area.

Several specimens have been found in the coal shales of the Labach coal seam near Saarlouis, Germany. Upper carboniferous.

Etoblattina euglyptica. Pl. 2, fig. 16; pl. 4, fig. 7.

Blattina euglyptica Germ., Verst. Steink. Wettin, vii, 86–87, tab. 31, figs. 7[a], 7[b], 8; — Gieb., Ins. Vorw., 315; — Heer, Viertelj. naturf. Gesellsch. Zürich, IX, 287; — Gold., Fauna saraep. foss., ii, 19.

Compare also the synonomy of *Etobl. Dohrnii*, *Gerabl. producta*, and *G. weissiana*.

The front wing is long and slender, having a very regular and rather strongly arcuate costal margin and a straight inner margin; the tip in the specimens known is broken, but there is no reason to suppose it to have been other than regularly rounded. The veins originate in the middle of the base, but immediately curve upward, so that the mediastinal area is narrow and equal, occupying about one quarter of the width of the basal half of the narrow wing, the main vein reaching somewhat beyond the middle of the wing, and emitting about nine oblique, simple branches. The scapular vein, curving somewhat strongly near the base, is beyond it nearly straight, rather distant from the mediastinal, and terminates at some distance short of the tip, commencing to divide at some distance before the middle of the wing, and emitting three or four long branches, which fork midway in their course, and are somewhat more longitudinal than the mediastinal branches. The externomedian vein is very similar to the preceding, and approximates it rather than the internomedian vein, while its course assumes the curve of the latter; it begins to divide at the middle of the wing, and emits three or four strongly divergent but nearly longitudinal branches, which fork again and occupy with these forks the entire apex of the wing, encroaching a little upon the costal and especially upon the inner margin. The internomedian vein is somewhat arcuate at the base, curving upward to above the middle of the wing, but afterwards extends to the inner margin in a nearly straight, arcuate course, terminating probably at some distance beyond the middle of the apical half of the wing, and emitting six or seven simple, oblique, straight, parallel and rather distant branches. The anal furrow is distinct, sharply arcuate, and terminates near the middle of the basal third of the wing, the four or more rather distant simple anal veins being subparallel to it but less curved.

Two specimens were described by Germar, both plainly belonging to the same species,[1] which is a large one, the wings measuring 10.5 mm. in breadth, and the longest fragment 31 mm. in length; the entire length was probably 33 mm., and the breadth to the length as 1 : 3.14. The specimens subsequently referred to this species by Goldenberg not only do not belong to it, but are referable to several distinct species (cf. *Etobl. Dohrnii*, *Gerabl. producta*, and *Gerabl. weissiana*).

Hind wing. One of the specimens figured by Germar has, besides the larger part of the left fore wing, broken fragments of the two hind wings, one of which, the left, we have reproduced on pl. 4, fig. 7. These show that the neuration of the hind wing was very similar indeed to that of the front wing. The mediastinal vein extended further toward the tip, but was somewhat similarly formed. The scapular vein had the same general arrangement and proportional extent. The same is true of the externomedian vein, excepting that the branches appear to be inferior instead of superior; but of the rest of the wing nothing can be d termined; the interspaces throughout are of the same width. From the distribution of the veins it would appear as if the anal field were plicated, and this Germar asserts, but the fractured condition of the fossil does not allow of certainty, so far as the illustrations show.

It would appear from Germar's figure that there is some difference in the venation of the two wings; the mediastinal area appears much longer, for instance, in the right than in the left wing. On the right wing an additional principal vein, the marginal, extends down, next the costal margin, as far as the middle of the wing, but this portion is broken from the left wing.

This species is one of the largest of the slender forms of Etoblattina, the front wing having at the same time a more equal width than usual. In this particular it differs from the preceding species conspicuously; from *Etobl. affinis*, to which it appears to be most nearly allied, it differs in its very much greater size and in the more distant neuration. From *Etobl. Dohrnii*, which was referred to the same species by Goldenberg, it differs in the course of the mediastinal vein, which is parallel to the costal margin; probably also by the smaller extent of the internomedian area apically; and by the form of the wing, which has a more strongly convex costal margin, and especially an arcuate base which bends the roots of all the veins downward, instead of leaving them straight as in the latter species; it is also a little larger.

The two specimens come from Wettin, Germany. Upper carboniferous.

[1] Giebel says that the two fore wings figured by Germar "show some differences, whose meaning will only be understood when perfect wings are discovered"; but the differences are so very slight that they cannot have specific value.

Etoblattina affinis. Pl. 2, fig. 2.

Blattina affinis Gold., Neues Jahrb. f. mineral., 1869, 159, taf. 3, fig. 3; — Ib., Faun. saraep. foss., ii. 19.

The front wing is long and slender, straight and a little tapering beyond the base; both costal and inner margin are nearly straight almost to the tip, which is well rounded. The veins originate a little above the middle of the wing, and curve a little upward in passing from the base. The mediastinal vein is arcuate, subparallel to the costal margin and rather close to it; the area occupies one-fourth the breadth of the wing, and terminates at some distance beyond the middle of the wing, emitting a large number of oblique, generally simple, approximate branches. The scapular vein is also arcuate but much more gently, rather distant from the mediastinal before branching, and terminates just before the extreme tip of the wing; it commences to divide near the middle of the wing, and emits about five long, straight, simple or simply forked branches, closely approximate, and preserving very nearly the direction of those of the mediastinal area. The externomedian vein has a course very similar to that of the preceding vein, commencing to divide at nearly the same point, and emitting three or more compound or irregularly forking, closely approximate, longitudinal veins, occupying at their extremity a narrow area at the apex and the extremity of the inner margin of the wing. The internomedian vein is gently arcuate, having a nearly straight course from scarcely above the middle of the base of the wing nearly to the end of the inner margin, emitting a large number of slightly sinuate, subparallel, simple or simply forked branches, oblique toward the base of the wing, and gradually more longitudinal toward the apex. Anal area unknown.

The single specimen known is perfectly preserved, with the exception of the minor veins near the base of the wings and the anal furrow; it is a small species, being only 17 mm. long, and 5 mm. broad, and the breadth to the length as 1 : 3.4.

This species is one of the slenderest of the smaller species of Etoblattina, and is peculiar for the straightness and gently tapering form of the front wing; in its form it most resembles *Etobl. leptophlebica*, from which it differs a good deal in neuration, and especially in the lesser breadth of the scapular area and the less crowded disposition of the veins. Goldenberg considered it as coming between this species and *Etobl. anaglyptica*, but its much closer affinity to *Etobl. flabellata* must be conceded; from this species it differs particularly in its straight costal edge and its longer mediastinal area; it is also a slenderer species. From the species which precedes it it is sufficiently separated by its very much smaller size, as also by the straight costal margin.

One specimen. Löbejün, Germany. Upper carboniferous.

Etoblattina flabellata. Pl. 2, fig. 4.

Blattina flabellata Germ., Münst. Beitr. z. Petref., v, 92, tab. 13, fig. 4[a], 4[b]; — Gieb., Deutschl. Petref., 637; — Heer, Viertelj. Naturf. Gesellsch. Zürich, IX, 287; — Gold., Faun. saraep. foss., ii. 19. (Not *Bl. flabellata* Germ., Verst. Steink. Wettin.)

Blattina anthracophila E. Gein., Neues Jahrb. f. Mineral., 1873, 694, taf. 3, fig. 2; — Ib., Verst. unt. Dyas Weiss., 4, taf., fig. 2. (Not *Bl. anthracophila* Germ.)

Compare also synonymy under *Gerabl. Münsteri.*

The front wing is long and slender, of only slightly unequal breadth, the costal border being gently convex and the inner border nearly straight until near the tip, while the tip itself is well rounded. The veins originate considerably above the middle of the base, and curve somewhat so as to be subparallel at first to the costal margin. The mediastinal vein is parallel to and not distant from the costal border, the area being less than one fourth the width of the wing, and terminates at or a little beyond the middle of the wing, emitting a considerable number of oblique, usually simple branches. The scapular vein is somewhat distant from the preceding and also runs very nearly parallel to the costal margin, along the base of the anterior third of the wing, terminating just before the tip of the wing; it commences to branch just as the mediastinal commences to bend toward the costal margin, and has four or five, generally simply forked, occasionally simple, branches, which have a direction very similar to that of the mediastinal branches, although much longer than they. The externomedian vein is rather strongly sinuate, commences to branch directly opposite the first dividing of the scapular vein, and emits at rather large angles four or five branches, which are usually forked once, but, in two of the specimens known, one of the forks of the second branch again divides; the branches occupy on the margin the entire apex of the wing, the main vein following very closely the course of the succeeding vein. The internomedian vein is also strongly arcuate, and beyond the middle of the wing assumes a more longitudinal course than before, extending the area very nearly to the extremity of the inner margin; toward the base this area, with the anal, occupies more than half the breadth of the wing, but it narrows rapidly beyond, and the vein emits a number of branches, the basal half of which are simple, straight, oblique, and comparatively distant, while the apical half of the same are simple or simply forked and considerably more longitudinal. The anal furrow is distinct, very strongly and regularly arcuate, and terminates at the end of the basal third of the wing; the anal veins are few, simple, similarly arcuate and parallel.

The species is a comparatively small one, the front wing measuring 15–17 mm. in length and 6–6.5 mm. in breadth, the breadth to the length being as 1 : 2.56. Geinitz describes his specimens as supplied with delicate cross-veins.

Germar described two species under this name, which I have of course retained for that bearing the earliest date, described in Münster's Beiträge. The other, described by Germar in his Carboniferous fossils of Wettin, is redescribed further on under the name of *Gerabl. Münsteri*, where also the points of departure will be noted. Dr. E. Geinitz, in his fossils of Weissig, has figured the present species with brief remarks, comparing it to Germar's *Bl. anthracophila*, and giving it that name in the explanation of the plate where it is figured; the points of resemblance pointed out by Dr. Geinitz are the simple character of the basal branches of the internomedian vein, the sudden assumption of a longitudinal direction of the same vein beyond the middle of the wing, and the simple character of the anal veins. With *Etobl. flabellata* he says it does not agree on account of the structure of the mediastinal area; but it is evident from this remark that he has compared it, not with the true *Etobl. flabellata*, but with *Gerabl. Münsteri*, and that his comparison is, therefore, in great measure justifiable. In all the points of his comparison with *Etobl. anthracophila*, howveer, it agrees even better with the true *Etobl. flabellata*, with which it also agrees in the distribution of the externomedian branches and in size, points in which it is at variance with *Etobl. anthracophila*. Had Dr. Geinitz compared his specimen with the illustrations of Germar's species as given in Münster's Beiträge, he would certainly have come to a different conclusion.

As indicated above, the species is very closely allied to *Etobl. anthracophila*, from which it differs in the points mentioned, as well as in the greater narrowness of the mediastinal area, and in the less arborescent branching of the extremity of the internomedian area. From *Etobl. affinis*, with which it agrees in size, it differs in its rather shorter mediastinal area, the wider interspaces of the externomedian area, and in the shape of the wing, the costal margin of which is more convex and the whole wing not so slender.

Germar's single specimen came from Wettin, Germany. Upper carboniferous. The two specimens described by Geinitz, from the lower dyas of Weissig.

Etoblattina anthracophila. Pl. 2, fig. 1.

Blattina anthracophila Germ., Münst. Beitr. z. Petref., v, 92–93, tab. 13, fig. 3; — Ib., Verst. Steink. Wettin, 84 ("? = *Bl. anaglyptica*"); — Gieb., Deutschl. Petref., 637; — Heer, Viertelj. naturf. Gesellsch. Zürich, IX, 287 ("= *Bl. anaglyptica*").
Compare the synonymy of *Etobl. flabellata.*

The front wing is of medium size, rather slender and regularly tapering, both costal and inner margin very gently convex, the tip broken in the only specimen known, but probably rather contracted and well rounded. The base of the veins is not preserved. The mediastinal vein terminates a very little beyond the middle of the wing, and the branches, the apical ones at least, are tolerably distant, simple, and a little curved; the area is rather broad, occupying in the middle more than a quarter of the breadth of the wing, and narrowing throughout nearly the whole of the apical half; the basal half or more unknown. The scapular vein is very closely approximated to the mediastinal, begins to divide before the middle of the wing, or opposite the last branch of the mediastinal, and has an arcuate course beyond this, the convexity downward, and terminates a little before the apex of the wing; the branches are about six in number, having a direction parallel to those of the mediastinal vein, simple or forked (in the specimen cited, the first two are forked, the others simple), and the branched portion of the area occupies about one-third of the breadth of the wing. The externomedian vein is broadly sinuous, its curve in the fragment preserved, and the location of the other veins, indicating that it curved rather strongly at base: it commences to branch with the scapular vein and emits two or more very long branches, the first of which is compound and the second simple in the specimen; the vein occupies a long and very narrow area in the middle of the wing, and on the margin the entire tip and a portion of the extremity of the inner border. The internomedian vein is also sinuous, being at first probably arcuate, then straight and very gradually approaching the inner margin, until a short distance beyond the middle of the wing, when it assumes a longitudinal direction, and finally curves downward to the border in the middle of the apical fourth of the wing; it throws off a considerable number of veins, those emitted before it assumes a longitudinal direction being straight, oblique, simple and rather distant, those beyond being simple and compound, and rather closely approximated. The anal furrow is rather strongly and regularly arcuate, terminating at about the end of the basal third of the wing: the anal veins, about six in number, are simple and subparallel to the furrow.

The species is of medium size, the fragment of the single front wing which is preserved measuring 24 mm.; the length of the wing is probably about 25 or 26 mm.; the breadth is 9.5 mm. in the middle, making the length to the breadth as 1 : 2.7, but the breadth is probably a little greater toward the base.

After describing this insect in Münster's Beiträge, Germar concluded that it was probably the same as his *Bl. anaglyptica*, described in the same place, and subsequent authors have accepted this assumption, apparently without any special examination of the matter, with the exception of Dr. E. Geinitz, who has referred to this species a wing described by him from Weissig. *Etobl. anthracophila*, however, differs from *Etobl. anaglyptica* in several important points: the mediastinal area is a little shorter; the branching of the scapular vein more closely resembles that of the mediastinal, originates farther towards the middle, and is less arborescent, and the distribution of the externomedian branches is less regular; besides this the shape of the wing, and especially the curve of the costal border, is very different. The wing referred by Geinitz to *Etobl. anthracophila* is, however, to be considered as belonging to *Etobl. flabellata* and not to this species, for the reasons mentioned in the remarks here appended to the description of *Etobl. flabellata*. Our present species is indeed closely allied to the last named, but may be separated from it by the greater breadth of the mediastinal area, the approximation of the scapular to the internomedian vein, the greater narrowness of the scapular area, the greater marginal extension of the externomedian area, and the more arborescent branching of the internomedian veins in the outer half of the wing; it is also considerably longer. It is also somewhat larger than *Etobl. weissigensis*, which stands very close to it, and differs also by the tapering form of the wing, the larger marginal area of the externomedian area, and in the branching of the veins of the same area; this is both less regular and commences much further toward the base of the wing; at the same time the vein itself is much less sinuous than in *Etobl. weissigensis*.

The single specimen known comes from Wettin, Germany. Upper carboniferous.

Etoblattina weissigensis. Pl. 6, fig. 5.

Blattina weissigensis E. Gein., Neues Jahrb. f. Mineral., 1873, 692–94, taf. 3, fig. 1; — Ib., Verstein. unt. Dyas Weiss., 2–4, taf., fig. 1; — Ib., Neues Jahrb. f. Mineral., 1875, 6; — Ib., Neue Aufschl. Dyas v. Weiss., 6.

The front wing is long, slender and equal, the costal margin rather gently and very regularly convex, the inner margin straight with a very slight and very broad median excision, the apex well rounded, and almost produced. The veins originate from the middle line of the wing, and curve rather gently upward before assuming a nearly longitudinal direction. The mediastinal is parallel to the costal margin, curving rapidly to meet it a little beyond the middle of the wing; the area occupies nearly a third of the breadth of the wing, and possesses comparatively few and very distant oblique branches, most of them rather deeply forked. The mediastinal vein is in close contiguity to the mediastinal, is also parallel or subparallel to the costal margin, and beginning to branch where the mediastinal begins to curve toward the margin, emits a considerable number (about seven) of rather crowded branches, most of which are simple, gently arcuate or sinuous, and while less oblique than those of the mediastinal area, are similar in distribution; in the single specimen known the first of the branches is compound, the rest simple; the vein terminates just before the tip. Beyond the basal curve the externomedian vein is straight until it branches, a little beyond the middle of the wing; beyond this it emits two or three sometimes forking branches, which are longitudinal and nearly approximated, so that the marginal extent of the area is very slight, occupying only the very tip of the wing. The internomedian vein, running contiguous with the preceding in the basal curve, parts rather rapidly from it, being directed at first toward the middle of the outer half of the inner border in a nearly straight course, until opposite the branching of the externomedian vein, when it assumes a slightly arcuate, longitudinal direction, and terminates just behind the tip of the wing; in the middle of the wing it is therefore very distant from the externomedian vein, which it afterwards rapidly approaches; in the basal portion, the distribution of the veins is very similar to that of the scapular area, but they are distant; beyond they are more frequent and arborescent, the branch originating at the point of change in the main vein, emitting a compound branchlet, which repeats the distribution of the branches of the main vein beyond it. The anal furrow is distinct, strongly arcuate, somewhat bent in the middle, rather distant from the internomedian vein and its first branch, and terminates at the end of the basal third of the wing: the anal veins are frequent, simple, arcuate and parallel to the furrow.

The wing is of rather small size, being 19 mm. long, and 6 mm. broad, or the breadth to the length as 1 : 3.17; the veins of the middle of the wing are very sharply defined, and the surface is delicately granulate.

Dr. Geinitz compares this species with *Etobl. anaglyptica* and *Etobl. leptophlebica,* and in a secondary way with *Bl. affinis.* It is indeed related somewhat closely to these species, and especially to the first named, and in form resembles best, though not very well, the two last named; but in essential features it has closer affinities with *Etobl. anthracophila,* which is somewhat larger than it, and is otherwise distinct from it by its general form and by the distribution of the branches of the externomedian vein, which divides much nearer the base, and occupies a larger marginal area than in *Etobl. anthracophila*; the branches of the basal portion of the internomedian vein are also much closer together in the same species.

The single specimen described by Geinitz came from Weissig, Saxony. Lower Dyas.

Etoblattina Dohrnii. Pl. 2, fig. 5.

Blattina euglyptica pars Gold., Neues Jahrb. f. Mineral., 1869, 162–63, taf. 3, fig. 8 (nec 9).
Not *Bl. euglyptica* Germ.
Compare also synonomy of *Gerabl. producta.*

The front wing is of a very regular shape, the tip being well rounded, and the upper and lower halves almost exactly alike in form, the costal and inner borders gently convex; the wing is largest in the middle, scarcely tapers toward the base, but more rapidly toward the tip, and especially near the apex. The veins originate together considerably above the middle of the wing, and have scarcely any, if any, basal curve. The mediastinal vein is straight, and terminates a little short of the extremity of the middle third of the wing, and emits, mostly from near its origin, half a dozen very long and unusually longitudinal simple veins; next the base the area occupies nearly one-third the breadth of the wing, and it tapers very gradually on its apical half. The scapular vein is also nearly straight, curved upward toward the costal margin only near the tip, and terminates just before the apex of the wing; it runs parallel to the costal margin along the middle of the anterior two-thirds of the wing, commences to divide before the middle of the wing, and emits only two or three simple or forked branches, having the course of the apical branches of the preceding vein. The externomedian vein takes a straight course nearly down the middle line of the wing, does not divide until past the centre, and then emits two or three compound or forking branches, which spread at a considerable angle and occupy the entire apex of the wing. The internomedian vein, scarcely arcuate throughout most of its course, and slightly more longitudinal toward the extreme tip, terminates on the inner margin just before the apex, opposite the extremity of the scapular vein, and emits only a few rather distant straight or occasionally forked branches.[1] The anal furrow is not very strongly arcuate, and terminates at about the end of the basal two-fifths of the wing; the anal veins, about five in number, are rather distant, similarly or less arcuate, mostly simple, or when forked, but slightly so.

The wing is of medium size, measuring about 26 mm. in length, and 10.5 mm. in breadth; or the breadth to the length is as 1 : 2.5.

The wing is peculiar for its symmetry of form, and the straightness and longitudinality of the veins, and particularly for the very longitudinal direction and basal attachment of the veins of the mediastinal area. It is not very closely allied to any species; from the true *Etobl. euglyptica*, which Dr. Goldenberg considered it to be, it differs in form and size, and in the branches of the mediastinal area; from *Gerabl. producta*, which Goldenberg placed in the same species, it differs in the brevity of the mediastinal area and the nature of the branches in the same, in the origin of the division of the externomedian vein, and in the gradual narrowing of the internomedian area. It is perhaps most nearly allied to *Etobl. weissigensis* and *Etobl. anthracophila*; from the former it is sufficiently distinguished by its form, as well as by the distribution of the apical branches of the internomedian area, and the great length of the branches of the mediastinal vein; from the latter by the nearly uniform breadth of the wing and the same peculiarities of neuration. I have placed the American *Etobl. Lesquereuxii* beside it, but it is not very nearly related, the branches of the mediastinal and also of the anal area being very different, while the whole wing in *Etobl. Lesquereuxii* is larger and much less bilaterally symmetrical.

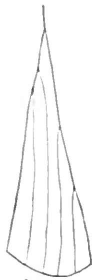
A single specimen is known, and was found at Wettin, Germany. Upper carboniferous.

Etoblattina Lesquereuxii nov. sp. Pl. 6, figs. 3, 4. (See also figure in text below.)

Front wing. This is long and slender, the costal margin very uniformly and considerably convex, the inner margin straight or scarcely convex, the whole wing nearly equal, the apical fifth tapering, the tip well rounded. The veins originate at about the middle line of the wing, the mediastinal and the united anal and internomedian in rather prominent ridges, the scapular and externomedian in a furrow between them; all together curve upward at first before assuming a more longitudinal direction, so that at the parting of the anal and internomedian veins, the anal area has more than half the width of the wing. The mediastinal vein runs subparallel to the costal margin, but continually and very gradually approaches it, much as in *Etobl. Dohrnii*, striking it at an unusually slight angle at a point a little beyond the middle of the wing; it emits about nine equidistant, and rather

[1] In my plate the anal furrow is incorrectly represented as being a forked vein; in reality the vein following the forked one is the anal furrow, so that there is one less vein in the internomedian area than is represented.

distant, simple, curving branches (the basal ones not represented on the plate), of which the basal ones are oblique while those beyond grow more and more longitudinal. The scapular vein runs very nearly parallel to the costal margin, most nearly approaching it where it first divides, a little beyond the end of the basal third of the wing, and then, passing in an arcuate course opposed to the curve of the costal margin, reaches the latter just before the apex of the wing; it emits about four branches, the terminal one simple, the others forked and the second even trebly, the general direction of all being less longitudinal than the apical branches of the mediastinal vein; at the widest the scapular area is two-fifths the breadth of the wing. Beyond the basal curve the externomedian vein is straight until it divides, at some distance beyond the middle of the wing, and up to this point it is unusually distant from the scapular vein on the one side and the internomedian on the other; at its division, that is, at the origin of its first branch, it turns abruptly but slightly downward, and runs subparallel to the apical portion of the costal border; its first branch is doubly forked, the offshoots inferior and thrown off at nearly equal distances from the origin to the tip of the branch; the two other branches of this vein are simple, longitudinal and nearly straight, the last arising before the end of the middle third of the wing, and the middle one midway between the first and third; all together occupy the entire tip of the wing; the origin of the middle branch being incorrectly given in our plate, a corrected figure of the apical half of the internomedian vein is here inserted. The internomedian vein is straight from a little beyond its separation from the anal to its last branch, and is thence feebly arcuate in a slightly more longitudinal course, terminating a little farther from the tip than the scapular vein; it emits four simple or forked, very distant, slightly arcuate branches; in the specimen upon which the description is based, the two middle branches are simple, the others forked. The anal furrow is very distinct, especially on the basal half, rather strongly and pretty uniformly arcuate, terminating at the basal two-fifths of the wing; the anal veins are numerous, being six or seven in number, and generally forked, often very deeply, and excepting the extreme short ones, are gently arcuate in the same sense as the furrow.



Etoblattina Lesquereuxii.

The wing is of medium size, being 25 mm. long, and 9 mm. broad, or the length to the breadth as 1 : 2.78.

It appears to present the under surface of a left wing, as the anal furrow is in relief. The principal veins and branches are also in delicate relief and distinct, excepting the anal veins. The surface of the wing is glistening and, excepting on the apical third, flat; toward the apex, and especially on the apical fifth, the interspaces are broadly furrowed, leaving the veins in sharp relief. In this part of the wing also, and indeed over nearly the whole surface, but less distinctly than here, the interspaces are broken by a delicate tracery of minute, irregular, pentagonal or rhomboidal cells, changing toward the base to a series of closely approximate, obscure, transverse lines, at right angles to the neighboring veins, and often forking feebly.

In the extent and distribution of the branches of the scapular and externomedian veins, as well as somewhat in the form of the wing, this species resembles *Etobl. weissigensis*, but it differs very much from it in the nature of the mediastinal vein, besides being a much larger insect. It agrees best with *Etobl. Dohrnii* in size and in the general limitation of the various areas, but the shape of the wing differs considerably, and the branches of the mediastinal vein arise at equal distances all along the principal vein; the anal area too is larger and more crowded with veins. From *Etobl. anaglyptica*, to which it is closely allied, it may be distinguished by the brevity, slenderness, and diminishing extent of the mediastinal area, as well as in the later division and more longitudinal direction of the externomedian vein. In the characteristics of the mediastinal and scapular areas and their relations to each other it resembles both *Etobl. affinis* and *Etobl. flabellata*, but it differs from both in the more apical division and different distribution of the externomedian branches. Finally it is readily distinguishable from the other American species of this genus, *Etobl. venusta*, in the nature of the mediastinal area, and the less arborescent distribution of the branches of the scapular vein.

The single specimen known was obtained by Mr. R. D. Lacoe; it is preserved on a piece of carbonaceous shale picked up near Pittston, Penn., in a pile of culm, and is considered by him as doubtless coming from the roof shales of the D seam of anthracite (of Prof. Lesley's classification). Middle carboniferous.

Etoblattina anaglyptica. Pl. 2, fig. 15.

Blattina anaglyptica Germ., Münst. Beitr. z. Petref., v. 92, taf. 13, fig. 2; — Ib., Verst. Steink. Wettin, vii. 84, tab. 31, fig. 4; — Gieb., Deutschl. Petref., 637; — Ib., Ins. Vorw., 314–15; — Heer, Viertelj. naturf. Gesellsch. Zürich, ix, 287; — Gold., Faun. saraep. foss., ii. 19.

Compare also the synonymy of *Etobl. anthracophila* and *E. labachensis*.

The front wing is long and tolerably slender, the costal border strongly arched, while the inner border is straight; the tip is broken, but is probably well rounded. The veins originate at some distance above the base, and probably curve upward a little[1] at first. The mediastinal area is very narrow, occupying not more than one-quarter the breadth of the wing, the vein running subparallel to the margin and terminating beyond the basal three-fifths of the wing; it emits a large number of rather closely approximated oblique branches, mostly simple, occasionally forked. The scapular vein is somewhat distant from the mediastinal, and has a broadly sinuate course, terminating shortly before the apex of the wing; in the middle of the wing the area occupies considerably more than one-third of its entire breadth, and, commencing to branch as far back as the end of the basal third of the wing, it emits three or four, mostly forked, sometimes doubly forked branches, having a direction very closely parallel to the branches of the mediastinal vein. The externomedian vein, beyond its basal curve, is very nearly straight, and terminates at the extremity of the inner margin, so that just the whole apex of the wing is occupied by the externomedian area; it commences to branch at some distance beyond the preceding vein, but still much before the middle of the wing, and emits three longitudinal branches, each of which forks nearly opposite the origin of the terminal branch of the scapular vein, and most of the forks again divide halfway to the tip, the whole being very regularly disposed. The internomedian vein follows the straight course of the externomedian to a short distance beyond the middle of the wing, the area thus rapidly narrowing, and then takes a

[1] This does not appear so well in our plate as in the representation by Germar in his Wettin fossils.

longitudinal course, reaching the margin only far toward the apex; before this turn in its direction, the vein emits three or four straight branches, most of which are simple, but the last one emits on the outer side a compound branch somewhat similar to the arborescent division of the main stem at its bend, which fills the apical half or more of the area with dichotomizing veins. The anal furrow is distinct, strongly and regularly arcuate, terminating near the end of the basal third of the wing; on account of the anterior origin of the main veins at the base of the wings, the anal area is nearly as broad as it is long, and the anal veins, which are numerous and approximate, are arcuate, parallel, and mostly simple.

The wing is of medium size, being probably 26 mm. long (the fragment preserved has a length of 25 mm.), and is 10 mm. broad; or the breadth is to the length as 1 : 2.5. The representation on my plate gives it a very little too small, and especially too short.

Germar subsequently placed his *Bl. anthracophila* with this species, but wrongly, as I have endeavored to show in my remarks under that species. Goldenberg at one time considered *Hermatobl. lebachensis* as a variety of this, but afterwards more correctly removed it from that category; for the principal distinction in this case also, see the remarks under that species. We have placed it between the two American species of this genus, not because it seemed most closely allied to them, but because their place in the series appeared to lie here. *Etobl. anaglyptica*, however, seems to be very closely related to *Etobl. venusta* in most of its features, but is smaller than it, has a proportionally smaller scapular field and a considerably larger externomedian field; the distribution of the apical branches of the internomedian vein is also more complex in this species than in *Etobl. venusta*; from *Etobl. Lesquereuxii* it is at once separable by the form of the wing and the greater breadth and extent of the mediastinal area. Among European species it is perhaps most nearly allied to *Etobl. mantidioides* and *Etobl. carbonaria*, but differs from both of them in much the same particulars as from *Etobl. venusta*; it is also larger than they, and especially than *Etobl. mantidioides*.

The single specimen comes from Wettin, Germany. Upper carboniferous.

Etoblattina venusta. Pl. 6, fig. 12.

Blattina venusta Lesq., Owen, 2d Rep. Geol. Ark., 314, pl. 5, fig. 11; — Heer, Viertelj. naturf. Gesellsch. Zürich, IX, 287; — Scudd., Geol. Mag., V, 176–77; — Gold., Faun. saraep. foss., ii, 19.

Front wing. The wing has an oblong subovate form, apparently resembling that of *Etobl. carbonaria*, so far as can be judged from the rather imperfect fragment which represents the American species; the costal margin, however, is nearly perfect, and is very regularly and considerably convex — more convex, perhaps, than in any other species of Etoblattina. Although the base of the single known specimen is broken, the veins by their curve appear to have arisen near the middle line of the wing, and to have been well arched in running from the base. The mediastinal vein runs subparallel to the costal margin, gradually approaching it in its apical half, and at last rather suddenly impinging on it, at about the end of the middle fifth of the wing; it emits an excessive number (sixteen or more) of mostly arcuate, simple or forked veins, closely crowded and subparallel, at base nearly transverse, at tip very oblique; in its middle the area is nearly one-fourth the width of the wing. The scapular vein runs subparallel to the costal border and rather distant from it, but does not have a regular curve, for it divides not far from the end of the basal third of the wing, and turns from the original course as much as does the branch; it appears, therefore, to be formed of two stems, and each of these emits in a similar manner three branches, the first two forked, the last simple; the distribution of the branches of this vein is therefore arborescent, the veinlets being mainly longitudinal, and together occupying all the space beyond the mediastinal vein almost, if not quite, to the tip. The externomedian vein has a broadly arcuate course, the apical portion of which is nearly straight; it begins to divide near the middle of the wing, opposite the secondary forking of the scapular vein, and emits four straight longitudinal branches, which, if they fork at all, only do so next the apical margin; they occupy a very slender field on the apical margin, apparently more below than above the very apex. The internomedian follows closely the course of the externomedian vein, being nearly straight in its apical half, and terminates shortly before the tip of the wing, emitting eight or nine long, arcuate, generally simple, occasionally forked branches, the apical ones more longitudinally disposed than the others, and all tolerably close. The anal furrow is strongly arcuate, and strikes the inner margin certainly before the middle of the wing, perhaps considerably before it; the few anal veins that can be seen appear to show that they are not very numerous and are arcuate next the anal furrow.

The wing is of a tolerably large size, the length of the fragment being 24.5 mm., the probable length of the wing from 28–30 mm., and the breadth of the fragment doubtless that of the whole wing, 12.75 mm.; the breadth to the length being about as 1 : 2.27. The upper surface of the wing is exposed, and is flat and admirably preserved; the veins at the base of the wing with their branches, as far as the forking of the scapular, are slightly raised; beyond this point, the principal veins, although elevated, are sulcate, and the branches of the mediastinal, scapular, and externomedian are feebly impressed, while those of the internomedian vein are slightly elevated; the anal furrow, in the part lying parallel to the first internomedian vein (the only part preserved), is impressed in its basal half, elevated in its apical half, and then indistinguishable in character from the first internomedian branch, excepting in being a little less sharply elevated and slightly broader; the cross veins are equally distinct or nearly so throughout the wing, and are slightly elevated, making a delicate tracery over the wings just indistinguishable by the naked eye; in the apical half of the wing they are nearly all straight and regularly transverse, but in the basal half, and especially in the central region of the wing, they are more sinuous and interlacing; this is especially true in the mediastino-scapular interspace, between the first and second branches of the scapular vein, and on either side of the externomedian vein where it first divides.

Although figured by Lesquereux nearly twenty years ago, this first known of American fossil cockroaches has never before been described, the remarks in the Arkansas report being only of a general nature. In the strongly curved outline of the costal margin, this species resembles *Etobl. anaglyptica*, with which it agrees also in the general distribution of the areas; it is undoubtedly more nearly related to this species than to any other, but differs from it in many minor points: the veins of the mediastinal area are much more frequent and crowded in *Etobl. venusta*; the branches of the scapular vein have a much more arborescent distribution, and its first branch has as many sub-branches as the main stem.

while in *Etobl. anaglyptica* it is only simply forked; the division of the externomedian vein commences farther from the base in *Etobl. venusta*, and the apical portion of the internomedian vein does not have a subarborescent distribution as in *Etobl. anaglyptica*. In the form of the wings and the distribution of the scapular branches, it shows a certain likeness to *Etobl. mantidioides*, but its much greater size and more extensive mediastinal area readily separate it from that species. The points in which it differs from the only other American species of the genus will be found mentioned under *Etobl. Lesquereuxii*.

A single specimen only has been found, which lacks the base and tip, and has a ragged inner margin. It is doubtful whether the dotted line in Pl. 6, fig. 12, by which I have indicated the supposed outline of the base, is correct, for the curves of all the veins would seem to indicate that too much is represented as lost; but as this would represent an anal area of unusual brevity, I have only indicated in the measurements given above the possibility of an error in my delineation.

It comes from Frog Bayou, Arkansas, and was obtained by Prof. Leo Lesquereux in black carbonaceous shale, with broken fragments of plants, overlying the thin seam of coal between the millstone grit and the subcarboniferous limestones; and if the period of deposition of the millstone grit was the same in the eastern and western coal deposits (see the introduction), is the oldest, as it was the first discovered of the American fossil cockroaches.

Etoblattina mantidioides. Pl. 3, fig. 8. (See also the figure on the opposite page.)

Blatta sp. Kirkby, Geol. Mag., IV, 389, pl. 17, fig. 6, 7.
Blattidium mantidioides Gold., Faun. saraep. foss., ii, 20.

The single known specimen of this species is composed of only the basal half or more of a front wing, so that it is impossible to give its shape with any certainty, or to be sure of the limit between the scapular and externomedian areas. The costal margin is regular and rather gently arcuate, and the inner margin, beyond the basal curve, is straight. This is inaccurately given in our plate as curved like the costal margin, and the terminal portion has therefore been incorrectly restored; it is far more probable that the shape of the wing was much as in *Etobl. carbonaria*, and a corrected figure is therefore given on the opposite page. The veins originate above the middle of the base of the wing, and have a gentle basal curve. The mediastinal vein is very short, almost reaching the end of the fragment, which certainly does not represent more than one-half of the costal border; it runs parallel to and not distant from this border, the area occupying less than a fourth of the breadth of the wing; it emits five or six simple or forked, parallel, oblique branches. Between the mediastinal and internomedian areas, near to the base of the wing, are three veins: whether the middle of these belongs to the upper or lower — *i. e.*, the scapular or externomedian — cannot be told from the broken specimen; it appears, however, to branch from the scapular, and this I deem to be the most probable relation of this vein, although it is otherwise indicated on the plate by the mark at the border; for on first study its approximation, toward the end of the fragment, to the internomedian vein seemed to render this its probable relation, and to make me then conclude that its basal union with the scapular was only apparent; subsequent study, especially in comparison with the species to which it appears most nearly allied, has since made the opposite appear the truth; and while one cannot be certain of one's ground with so imperfect a fragment, the comparison of this fragment with the more perfect relics of the species near which I have now placed it will convince any one, I think, that its true affinities are here, and that the middle main branch probably belongs accordingly to the scapular vein. Supposing this to be so, the scapular area is very extensive, terminating probably at or scarcely above the tip of the wing, and occupying in the middle of the wing nearly half its width; the vein branches very near the base, and each branch divides dichotomously several times, sending forth longitudinal shoots, which in the upper branch at least show, by a certain obliquity, signs of a similarity to the veins of the mediastinal area. The externomedian vein branches dichotomously like the lower branch of the scapular vein, commencing a little before the middle of the wing; the branches approximate, at least at first, but afterwards probably spread in more or less of a fan shape. The internomedian vein is gently oblique and very slightly sinuous, and, to judge by its assuming toward the end of the fragment a more longitudinal direction, probably terminates far out on the inner margin toward the tip of the wing, the area occupying nearly half the breadth of the wing at the middle; it emits a number of parallel, oblique, forked, rather distant branches. The anal furrow is strongly and regularly arcuate, terminating at not far from the end of the basal third of the wing; the anal veins are rather numerous, subparallel, nearly straight and usually forked, the forks sometimes terminating on the neighboring veins or on the anal furrow, and so presenting a confused appearance.

Etoblattina mantidioides.

In addition the wing is described as having the front margin produced and flattened. The fragment is nearly 11 mm. long, representing a wing of comparatively small size, probably about 18 mm. long; the breadth is about 8 mm.; the restored portion in the plate is represented as much too short, the breadth to the length being about as 1 : 2.25. The annexed cut is more nearly correct in this particular. Besides the single specimen described, another fragment, showing one or two veins only, occurred with it, and probably belongs here, for both are similarly marked by a fine and irregular reticulation.

If we have correctly interpreted the parts of this wing, the species is somewhat closely allied to *Etobl. carbonaria*, although certainly distinct from it by the brevity of the mediastinal area and the different distribution of the branches of the scapular vein. In the brevity, although not in the width of the mediastinal area it approaches *Etobl. leptophlebica*, but the wing does not appear to be so slender, and the distribution of the branches of the scapular vein is again different: from *Etobl. russoma*, with which it agrees in general features, it differs in its smaller size and the brevity of the mediastinal area; while from *Etobl. flabellata*, with which it agrees very well in the extent of the mediastinal area, it differs by the very different distribution of the branches of the externomedian vein.

The single specimen came from "the north bank of the Wear, opposite to Claxheugh, about two miles from Sunderland," Durham, England; from "very near to the top of the coal-measures, as developed in Durham." Upper carboniferous, according to the recent classification of Hull.

Etoblattina carbonaria. Pl. 2, fig. 3.

Blattina carbonaria Germ., Verst. Steink. Wettin, vii. 85–86, tab. 31, figs. 6ᵃ, 6ᵇ; — Gieb., Ins. Vorw., 315; — Heer, Viertelj. naturf. Gesellsch. Zürich, IX, 287, No. 3 (not 288, No. 15); — E. Gein., Neues Jahrb. f. Miner., 1875, 5: — Ib., Neue Aufschl. Dyas v Weiss., 5; — Gold., Faun. saraep. foss., ii. 19, No. 3 (not 20, No. 34).

The front wing has a somewhat obovate form, the costal border being very regularly and rather strongly convex; the tip is broken in the single specimen known, and the inner border is not continuous, so that its contour cannot be certainly determined, but it appears to be gently convex. The veins start from some distance above the middle of the wing, and curve upward considerably before assuming a longitudinal course. The mediastinal vein continues subparallel to the front border, and terminates scarcely before the middle of the apical half of the wing, emitting seven or eight very oblique, usually forked branches; the area is narrow, scarcely occupying one-fourth the breadth of the wing. The scapular vein has a sinuous course, diverging slightly from the costal margin and from the mediastinal vein in the basal half of its course, afterwards converging and terminating barely before the tip of the wing:[1] it commences to divide far before the middle of the wing, and anterior to several branches of the mediastinal vein; its branches are numerous (seven or more), and simple or forked, having in this respect as in direction, although not at all in length, a resemblance to the mediastinal branches; the mediastinal area occupies two-fifths the breadth of the wing. The externomedian vein beyond its basal curve is nearly straight, and terminates at some distance before the end of the inner border, so that the area occupies rather broadly the lower outer angle of the wing; the vein commences to branch a little beyond the middle of the wing, and emits three or four simple or compound branches, which, like those of the preceding areas, are pretty closely crowded. The internomedian vein follows closely the course of the externomedian, so that the area narrows regularly and rather rapidly: the vein emits six or seven simple or simply forked branches, which are pretty straight, oblique, and more distant than those of the other areas. The anal furrow is well impressed, strongly arcuate, and terminates near the end of the basal third of the wing, while the anal veins are subparallel to it, simple, and rather closely crowded.

This gracefully formed wing might well stand as the type of this group of fossil cockroaches; it is of medium size, the length of the fragment being 20 mm.; the probable length of the wing is 22.5 mm., and its breadth is 8.75 mm.; or the breadth to the length as 1 : 2.57.

The pronotal shield attached to the wings has a parabolic outline, the hind border, however, strongly convex: the broadest part is scarcely in front of the middle of the posterior half, where the breadth equals the length; in front of this it tapers rapidly. Length, 9.5 mm.

The wing has much the same shape as *Etobl. manlidioides*, from which it differs in its larger size, the greater length of the mediastinal area, and the distribution of the branches of the scapular and externomedian veins. It also approaches the American *Etobl. venusta*, which is larger than it, but agrees better in the mediastinal area, and to a large extent in the branches of the scapular vein; in *Etobl. venusta*, however, this first divides still further toward the base of the wing; and the branches of the externomedian vein are also simple in the American species and compound in the European. From *Etobl. didyma* it differs by its very much smaller size, the narrowness of the mediastinal area, and the distribution of the externomedian branches.

Germar described the species from seven individuals from Wettin, Germany. Upper carboniferous. Geinitz mentions a specimen from Weissig, Saxony. Lower Dyas. (But as no description or figure is given, this may be looked upon as dubious.)

Acridites carbonaria, referred by some authors to Blattina, appears to be a Neuropteron.

[1] The area of this vein is represented on our plate as smaller than it should be, and the restored outline is also probably too contracted, throwing the extremity of the vein at the extreme tip of the wing.

Etoblattina didyma. Pl. 2, fig. 13.

" *Dictyopteris didyma* Rost. Dissert. flor. Wettin, 21."

Blattina didyma Germ., Münst. Beitr. z. Petref., v, 92, tab. 13, fig. 1^a1^b; — Ib., Verst. Steink. Wettin, vii, 83, tab. 31, figs. 2, 3; — Quenst., Handb. Petref., tab. 24, fig. 16; — Gieb., Deutschl. Petref., 637; — Ib., Ins. Vorw., 314; — Pict., Traité Pal., 2e éd., II, 362, pl. 40, fig. 2; — Heer, Viertelj. naturf. Gesellsch. Zürich, IX, 287; — Ib., Faun. saraep. foss., ii, 19.

Not *Blattina? didyma* Germ., Verst. Steink. Wettin, vii, 87, pl. 31, fig. 10; nor *Bl. didyma* Gein., Neues Jahrb. f. Mineral.; nor *Blatta didyma* Germ.-Ber., Org. Reste Bernst., II, 34–35.

Compare the synonymy of *Anthracobl. sopita.*

The front wing is long and nearly equal, the costal margin regularly and considerably convex, the inner margin almost straight until near the tip, the apex broadly and regularly rounded. The veins appear to originate somewhat above the middle of the base, but about the middle line of the wing. The mediastinal vein runs parallel to the costal margin at about the middle of the anterior half of the wing, and terminates by a somewhat rapid curve upward at about the middle of the apical half of the wing; it emits a large number of not very closely crowded simple or forked oblique branches. The scapular vein, beyond its basal curve, has a nearly longitudinal course, but apically bends upward somewhat abruptly,[1] and terminates just before the tip of the wing; it first divides at about the end of the basal third of the wing; its first branch is compound, but the others, two or three in number,[2] are simple; the vein is very distant from the mediastinal, so that the area, at its widest, occupies nearly one-half the breadth of the wing. The externomedian vein also divides early, before the middle of the wing, and occupies with its branches the entire broad apex of the wing, and encroaches slightly on the inner margin; it emits first a compound arborescent branch, and then several simple branches, the latter terminating below the extreme apex. The internomedian vein, beyond its basal curve, is nearly straight, and terminates a little before the apex of the wing, emitting eight or nine simple or occasionally forked, somewhat sinuous, oblique branches, besides, in the only example known, a single superior branch parallel to the main vein.[3] The anal furrow is well impressed, strongly oblique, and terminates at the end of the basal third of the wing; the numerous anal veins which follow it are similarly but more gently curved and simple or forked.

The wing figured by Germar is a little broken at the base, but otherwise nearly perfect, for although the apical margin is represented as doubtful by Germar, its agreement with the tips of the veins renders it almost certainly correct; the wing thus preserved is 40 mm.

[1] This is the way it is represented in Germar's larger and presumably more correct figure in his Wettin fossils; in his smaller figure it has no such abrupt bend.

[2] Different in the several figures by Germar.

[3] It is impossible, from Germar's figures, to be quite sure that the lowest two or three branches of the externomedian vein do not belong to this superior branch of the internomedian vein, which latter would then have the peculiar disposition common to *Etobl. anaglyptica* and other allied forms; but the mode of distribution of the branches of the main internomedian vein beyond the origin of this superior branch is very regular, while in all those species in which the internomedian vein changes from an oblique to a longitudinal course and is accompanied by an arborescent disposition of the apical branches, this portion of the area is either itself filled with similar arborescent branches, or is at least irregular. In his description Germar also assigns these doubtful branches to the externomedian and not to the internomedian vein, and we may therefore reasonably follow the same course.

long and 15 mm. broad,[1] and is therefore the largest, or one of the largest, of the species of this genus; the breadth is to the length as 1 : 2.67; with a lens the entire surface is seen to be covered with a delicate network of cross veins, connecting the veins by exact transverse lines.

The two species to which this insect is the most nearly allied are those between which it is here placed. From both it is at once distinguishable by its far greater size; from *Etobl. carbonaria* it differs in the less extent of the scapular area, the fewer number of veins in the same area, and its earlier division. From *Etobl. russoma* it is separated by its narrower and longer mediastinal area, and the less profuse branching of the scapular and externomedian veins.

Germar described the species from a single specimen and its reverse, found at Wettin, Germany. According to Mahr, the species has been repeatedly found at Manebach, near Ilmenau, Germany. Upper carboniferous.

Acridites carbonaria, considered by some authors as the hind wing of this insect, is rather to be looked upon as neuropterous. *Blatta didyma* Germ.-Ber., is an amber insect, which does not belong to the Palaeoblattariae.

Etoblattina russoma. Pl. 2, fig. 6.

Blattina russoma Gold., Neues Jahrb. f. Mineral., 1869, 159, taf. 3, figs. 2a, 2A, 2B; — Ib., Faun. saraep. foss., ii, 20.

The front wing is tolerably broad, the costal margin very regularly and rather strongly convex, the inner margin nearly straight to the tapering, well-rounded tip. The veins originate far above the middle of the wing, and have a slight upward curve for a short distance. The mediastinal vein runs subparallel to the costal border, which it approaches apically in a very gradual manner, and terminates shortly before the end of the middle third of the wing; the area is less than one-fourth the breadth of the wing, and is filled with seven or eight simple or forked, straight, oblique branches. The scapular vein has a broadly but rather strongly sinuous course, running parallel to the costal margin in the basal two-thirds of the wing, and beyond that curving toward the margin, terminating just before the tip; it begins to divide in the middle of the basal half of the wing, and emits about five branches, which become less and less compound apically, but terminate on the margin in about a dozen closely crowded branches; this area occupies more than one-third the breadth of the middle of the wing. The externomedian vein is broadly and rather strongly arcuate next the base, afterwards nearly straight, terminating at some distance before the end of the inner border; it commences to divide at some distance before the middle of the wing, but further out than the scapular vein, and bears a couple of compound branches, which subdivide irregularly many times, and fill with numerous veins an area larger than usual in this genus, occupying upon the margin not only the whole of the apical border, but an equal extent of the extremity of the inner border. The internomedian vein is parallel and close to the externomedian vein throughout its course beyond the basal curve, and emits about half a dozen long, generally simple and nearly straight branches, parallel to and rather distant from one another; so rapid is the narrowing of the

[1] Germar gives the measurement as 30 mm. long and [illegible] evidently by mistake, as it disagrees both with the dimensions of his unenlarged figure and his German measurements (18 lines long by 6 lines broad); these latter are also inaccurate, as the wing is not three times as long as broad. The figures we have taken are from measurements of the smaller figure in the Wettin fossils.

area, that its length along the inner margin is only a little longer than its longest basal branch. The anal furrow is strongly impressed and its basal two-thirds very strongly arcuate, while the apical third is straight, terminating some distance before the middle of the wing; the anal field, notwithstanding its unusual length, is almost as broad, and is filled with about eight arcuate, moderately distant veins, most of which are simple, those nearest the furrow subparallel to it, the others curved in an opposite direction.

The wing is peculiar for the prominence of the lower basal angle, which in nearly right-angled, and for the corresponding extent of the anal area; it is of medium size, measuring 25 mm. in length and 10.5 mm. in breadth, the breadth being to the length as 1 : 2.38. Only a single specimen is mentioned as having been found, which is perfect but for the obliteration of parts of one or two veins at the tip of the internomedian area.

Goldenberg compares this species to *Etobl. carbonaria*, remarking that it agrees best with it in size and shape, but must be considered specifically distinct on account of the peculiar venation of all the areas, and especially of the combined scapular and externomedian areas (Mittelfeld), which has nearly double as many branches as in *Etobl. carbonaria*; he also mentions the peculiar branching of the externomedian vein by which the vein, beyond its last fork, runs free to the margin, parallel to an offshoot from the last branch of the same vein; and also the shoulder at the base of the wing, which is wrinkled and projects as a sharp angle. Although certainly very closely allied to the species mentioned, *Etobl. russoma* differs further from it in the less frequent forking of the mediastinal veins, in the earlier division of the scapular and externomedian veins, the doubly forking basal branch of the former, the greater irregularity in the branching of the latter, and in the much more rapid narrowing of the internomedian field. It also differs a little in its greater size, but it is not true that the combined scapular and externomedian areas have nearly double as many branches as in *Etobl. carbonaria*; the broken tip of the latter will not allow us to determine just how many there are, but there is room for additional branches in the broken portion, and those actually visible are eighteen, against twenty-five at the very margin of *Etobl. russoma*; or if we take each vein separately, we find in the nearly perfect scapular vein of *Etobl. carbonaria* eleven branches, against twelve in *Etobl. russoma*; in the externomedian vein of the former, which is certainly very imperfect, seven veins, against thirteen in the latter—a difference which is nearly double, but which is unquestionably due, in part at least, to the imperfect state of the only known fragment of *Etobl. carbonaria*. From *Etobl. didyma*, *Etobl. russoma* differs in nearly all the points by which it may be distinguished from *Etobl. carbonaria*, and, besides, differs considerably from it by its smaller size and less symmetrical shape, and the more frequent division of the scapular and lower externomedian branches. From *Etobl. leptophlebica* it differs in its broader and rounder form, and the much smaller extent of the scapular and internomedian areas, as well as in the fuller expansion of the externomedian area.

A single specimen was found at Löbejün, Germany. Upper carboniferous.

Etoblattina leptophlebica. Pl. 3, fig. 9.

Blattina leptophlebica Gold., Neues Jahrb. f. Mineral., 1869, 158–59, taf. 3, figs. 1a, 1b; — Ib., Faun. saraep. foss., ii. 19.

The front wing is long and slender, tapering, and straight; the costal margin is very gently convex, the inner margin straight, but the tip of the only specimen is broken.

The veins originate considerably above the middle of the wing, and curve slightly upward from the base before becoming longitudinal. The mediastinal vein is gently arcuate, runs for a short distance parallel to the border, then curves gently toward it, and terminates at about the middle of the wing; the area occupies nearly one-third the width of the wing, and is filled with half a dozen forking, occasionally simple, oblique branches. The scapular vein, beyond the common clustering of the veins at the base, parts rapidly from the mediastinal, and pursues a broadly arcuate course, at first divaricating slightly from the costal margin and afterwards gradually approaching it, and terminates probably just before the tip of the wing; in the apical half of the wing it runs as far as the middle line of the wing, making the area of unusual width; it emits about eight singly or doubly forked branches (with occasionally a simple one), which are therefore long and closely crowded, and assume a direction parallel to the mediastinal veins and very similar; the branching commences in the middle of the basal half of the wing, as far back as the first division of the internomedian vein. The externomedian vein is nearly straight, but very gently and broadly sinuous beyond the basal curve, and terminates probably not far before the apex, leaving for the area a small marginal extent over the probably narrow apex and lower outer angle of the wing; notwithstanding the slenderness of the area, the vein commences to branch before the middle of the wing, and emits three or four simple or forked branches (most of them probably forked near the tip, which is broken), which have a longitudinal course. The internomedian vein runs side by side with the preceding, and emits first a series of comparatively distant nearly straight and simple veins, about four in number, which occupy about one-half of the rather gradually narrowing area; these are followed by a forked and then by a compound branch, whose forks fill the narrowing apex. The anal furrow is strongly impressed, stout, strongly and very regularly arcuate, and terminates at the end of the basal two-fifths of the wing; the anal veins are mostly simple, occasionally feebly forked, very numerous, and very crowded, especially away from the furrow; next the furrow they are rather gently arcuate, gradually becoming nearly straight or sinuous.

The wing is peculiar among its immediate congeners for its straight and tapering slender form, recalling exactly that of *Etobl. affinis*; it is also peculiar for the extreme breadth of the scapular area, due to the deep sinuosity of the scapular vein. It is a comparatively small species, the wing being probably only 19.5 mm. long (the fragment preserved measures 16.5 mm.), and is 7 mm. broad in the middle; or the breadth is to the length nearly as 1 : 2.8. To judge from Goldenberg's figures (he makes no mention of the fact), the base of the mediastinal area is obscurely striate longitudinally, and the rest of the wing, or at least around the anal furrow, very minutely and very obscurely reticulate, with three or four rows of polygonal cells in each interspace.

This species cannot be confounded with any other, for it is widely separated from all with which from its size and form it might be compared, by the broad scapular area, whose long branches simulate the distribution of those in the unusually short mediastinal area; it is most nearly allied to *Etobl. russoma*, where the general distribution of the branches in the much smaller scapular area is similar, as is also the early branching of this vein and the externomedian; but the form of the wing, the short mediastinal area, and the much narrower and more gently tapering internomedian area of *Etobl. leptophlebica* at once distinguishes it from *Etobl. russoma*. It was compared by Goldenberg to *Etobl. anaglyptica*, on account of the form of the wing, but besides differing considerably in the points of neuration mentioned by Goldenberg, and by others, has a much less convex costal margin and a more regularly and gently tapering form.

The single specimen comes from Löbejün, Germany. Upper carboniferous.

Etoblattina manebachensis. Pl. 2, fig. 11.

Blattina manebachensis Gold., Neues Jahrb. f. Mineral., 1869, 160, taf. 3, fig. 1; — Ib., Faun. saraep. foss., ii. 19.

The front wing is long obovate, both margins being somewhat similarly curved, although the inner is more strongly and more regularly convex than the costal margin, the latter being straight in its middle half; the tip is neither broadly rounded nor produced; the veins originate slightly above the middle of the wing, and curve upward gently before becoming straight; beyond this they are all unusually straight. The mediastinal vein runs parallel to, and tolerably distant from, the costal margin in the basal half of its course, the area here occupying a little less than a third of the breadth of the wing; beyond, the vein gradually approaches the margin, meeting it only a little beyond the middle of the wing; it emits half a dozen or more simple or simply forked oblique branches. The scapular vein is very straight, scarcely curved at the extremity as it approaches the border, just before the apical margin of the wing; it runs subparallel to the costal margin, commences to divide at the end of the basal third of the wing, and has about five branches; the basal one compound, the next forked, and the others simple, all taking the course of the mediastinal branches, and together occupying an area from one-fourth to one-third the width of the wing. The externomedian vein commences to divide scarcely earlier than the scapular vein, and emits about as many branches, which are simple, straight and longitudinal for a long distance, commencing to divide only opposite the origin of the last branch, when they fork almost simultaneously, the first again dividing; the area occupied by them is very regularly wedge-shaped, and at the margin occupies the entire apex of the wing. The internomedian vein runs very close and parallel to the preceding vein, being arcuate at the base and beyond straight, meeting the lower border opposite the tip of the scapular vein; it emits seven or eight, generally simple, occasionally forked, nearly straight, parallel, oblique, and rather distant veins. The anal furrow is well impressed, strongly arcuate, but straightened apically, striking the margin a little beyond the basal third of the wing; the area covers about two-fifths of the width of the base of the wing, and is occupied by eight or nine simple or deeply forked veins, arcuate next the anal furrow, straight and crowded toward the inner angle.

The wing, by the similarity of its margins, differs from most Etoblattinae, *E. Dohrnii* alone resembling it closely; it is also peculiar for the extreme straightness of its principal veins. It is of medium size, the single specimen known being a perfect fore wing, 25.5 mm. long, and 10 mm. broad; or the breadth is to the length as 1 : 2.55. From *Etobl. Dohrnii*, which it so closely resembles in general form, and in the straightness of the veins, it is readily distinguished by the crowding of the branches, the brevity of the mediastinal vein, and the early division and numerous branches of the externomedian vein. It is larger than, and not so tapering as, *Etobl. leptophlebica*, besides being immediately distinguished by the straightness of the scapular vein. From *Etobl. elongata* it is abundantly distinct by its broader form, and by the straightness of the apex of the scapular vein. The straightness of the veins will also distinguish it from *Etobl. anthracophila*, with which it agrees in many points. Goldenberg compares it to *Etobl. primaeva*, with which it has certain resemblances indeed by the straightness of the veins, and the early division of the externomedian vein, but from which it differs in nearly every other point of its structure, and from which it may be distinguished at a glance (to mention no other points), by having scarcely one-half the breadth of the larger species.

A single specimen from Manebach, near Ilmenau, Germany. Upper carboniferous.

Etoblattina elongata. Pl. 2, fig. 10.

Blattina sp. ("cf. *Mahri*") E. Gein., Neues Jahrb. f. Mineral., 1875, 5, taf. 1, fig. 2;—Ib., Neue Aufschl. Dyas v. Weiss., 5, taf. 1, fig. 2.

The front wing is so imperfect in the only specimen known, that it is difficult to describe its form; yet to judge of the apical half, which only is preserved, it is the very slenderest of the species of Etoblattina, although nearly as long as the largest; the two margins approach each other gradually and equally in this apical half, making the tip exceptionally narrow, although it is well rounded. Only the tip and a portion of two branches of the mediastinal vein can be seen, by which we should judge that the vein was rather long, terminating only a little before the apical third of the wing, and had a number of rather distant, straight, oblique and simple branches. The scapular vein runs parallel to the costal margin until close to the tip, when it curves toward the margin, which it strikes scarcely before the extreme apex of the wing; it begins to divide near the middle of the wing, emits half a dozen straight, oblique, simple, rather distant branches, quite parallel to those of the mediastinal area, and occupies near the middle two-fifths, next the apex one-half, the width of the wing. The externomedian vein divides opposite the division of the scapular vein, the forks parting but slightly and again dividing (doubly) only shortly before the tip, so that this vein is unusually distant from the veins on either side of it, and occupies on the margin a narrow area, including most of the tip and the apical portion of the inner border. The internomedian vein probably changes its early course (after being directed, in the unknown basal half, more obliquely toward the inner margin), for the portion in the apical half is nearly longitudinal and nearly straight, curved downward toward the border very slightly; it terminates at a little distance before the tip, and emits two or three extremely distant simple branches.

Geinitz describes the surface of the wing as delicately granulate, and apparently of a somewhat rigid, parchment-like consistency. The fragment is 18.5 mm. long, and 11 mm. broad; the whole wing was probably 35 mm. long and scarcely more than 11 mm. broad, the breadth to the length being as 1 : 3.2; it is, therefore, the largest of the slender, or the slenderest of the larger species, and is peculiar for its tapering apex. In the straightness of its veins it resembles the preceding species as well as *Etobl. Dohrnii*, but is abundantly distinct from either by its slenderer form. The only other species which has such a tapering tip is *Etobl. parvula*, a much smaller and less slender form. Geinitz considered it as probably the apex of the wing of *Gerabl. Mahri*; the infrequency of the branches indeed make it resemble that species in a general way, but it is difficult to compare it with that from the fact that the only specimen of *Gerabl. Mahri* known has lost almost the whole of the tip; but there is a single point which is indisputable, and that is the excessive length of the mediastinal vein in *Gerabl. Mahri*, which reaches the apex where that of the scapular vein impinges on the border in *Etobl. elongata*; it is, therefore, plainly impossible that they should be properly considered the same.

A single specimen is mentioned by Geinitz from Weissig, Saxony. Lower Dyas.

Etoblattina parvula. Pl. 2, fig. 9.

Blattina parvula Gold., Neues Jahrb. f. Mineral., 1869, 161, taf. 3, fig 6; — Ib., Faun. saraep. foss., ii, 19.

In form the front wing of this species agrees pretty well with that of the last, but it is not so slender; both costal and inner margins have a similar and pretty strong convexity, and the wing tapers rapidly and pretty regularly to a somewhat pointed tip, the very apex of which is rounded. The veins spring from a common point, above the middle of the base of the wing, and have scarcely any basal curve. The base of the mediastinal area is, therefore, about one-third as wide as the wing at that point, and the mediastinal vein, very gradually approaching the costal margin, strikes it nearly at the end of the middle third of the wing; it emits half a dozen or more simple, oblique, slightly arcuate branches. The scapular vein is nearly straight, curving only near the tip, and, running subparallel to the costal margin, occupies with its branches a variable width of the wing, reaching the middle line in the apical half; it commences to divide at some distance before the middle of the wing, and emits about half a dozen simple, straight branches, the first one of which is forked near the tip, and all have a direction similar to, but a little more longitudinal than, the mediastinal branches; the vein terminates exactly at the apex of the wing. The externomedian vein, emitting near the middle of the basal half of the wing a straight, apically forked branch, which runs close and parallel to the scapular vein, itself bends downward, and then turns out again, and continuing nearly parallel to its first branch, ends some distance beyond the middle of the apical half of the inner border, emitting a couple of equidistant, straight and simple branches on the way; on the border, then, this area occupies the apical fifth of the inner margin. The internomedian vein runs in close proximity to the last vein, and has, therefore, a rather deeply sinuous course, and emits three or four, basally curved, apically forked branches. The anal furrow is very deeply impressed, strongly arcuate, terminating near the end of the basal third of the inner border, and leaving the area nearly as broad as long; the anal veins of the upper half of the area are obscured; in the lower half they are thickly crowded, nearly straight, unusually longitudinal and deeply forked.

This is one of the very smallest species, the front wing measuring only 9 mm. in length, and 3.75 mm. in breadth, the breadth being to the length as 1 : 2.4. In its minute size it differs from all but the succeeding species, which agrees well, as Goldenberg remarks, with that of the living *Ectobia lapponica* (Linn.); but it is peculiar, among palaeozoic cockroaches, for the shape of the wing and the distribution of the branches of the lower veins of the wing. It is most nearly related to *Etobl. elongata*, which is many times its size and is a slenderer species. It agrees in size with *Etobl. insignis*, but the course of the internomedian vein is very different, and all the veins and their branches are distinct instead of being nearly obliterated, as in that remarkable species.

A single specimen from Löbejün, Germany. Upper carboniferous.

Etoblattina (?) **insignis.** Pl. 2, fig. 7; pl. 4, fig. 9.

Blattina insignis Gold., Vorw. Faun. Saarbr., 17; — Ib., Faun. saraep. foss., i, 17, taf. 2, fig. 11; — Ib., Faun. saraep. foss., ii, 20, 51; — Scudd., Mem. Bost. soc. nat. hist., iii, 19.

The front wing of this insect seems to have very nearly the same form as that of the preceding species, but has perhaps a little fuller anal area, and a less pointed tip. It is not at all clear from what point the veins originate, and it is doubtful whether they have a common origin. The veins are all exceedingly obscure, and even the limits of the areas are doubtful. The mediastinal area appears to have a width of one-third that of the wing at the base, and the vein seems to terminate at about the end of the middle third of the wing. The scapular vein is apparently nearly straight, running down the middle of the wing, and terminating at the tip. The externomedian probably occupies a narrow area; it can hardly divide before the middle of the wing, and on the margin covers the apical third of the inner border. The internomedian vein probably terminates at the end of the middle third of the wing, perhaps farther out, and is supplied with closely crowded forking veins. The anal furrow is deeply impressed, arcuate, and rather bent in the middle, and terminates at the end of the basal third of the wing. No branches of veins can be made out, to judge from Goldenberg's drawing, excepting in the internomedian area.

The two front wings are present in the only specimen yet discovered, one broken at the tip, the other along the inner margin; between these two the form of the wing can be accurately determined, but the tip is represented inaccurately in Pl. 2, fig. 7, as fully rounded, whereas its form should be much as in *Etobl. parvula*. With that species, it is the smallest known, the front wing measuring but 9 mm. in length, and 4.25 mm. in breadth, the breadth being to the length as 1 : 2.12.

Goldenberg remarks, that from the slight traces of the veins, the texture of the front wings of this insect was probably similar to that of those of Corydia and Phoraspis.

Hind wing. The hind wing of this species closely resembles the front wing in form and size, and could scarcely have possessed a plicated anal area; the neuration, too, is nearly as obscure as in the front wing, throwing some doubt upon the presumed thickened consistency of the front wing, since, in living insects, the hind wing is always membranous. In the original drawings of this insect, which formed the basis of Goldenberg's plates, and which Dr. Goldenberg has been kind enough to send me for study, the two hind wings are not quite alike, the left wing, which I have reproduced in outline in Pl. 4, fig. 9, being considerably more pointed and narrower than the right wing; the two wings show, also, a somewhat different arrangement of veins, although these are very obscure in both; next the front wing, which hides a portion of the costal area, there are in the left wing several longitudinal parallel veins, which cannot be made out in the right; and the rest of the wing, or fully two-thirds of it, is made up of a single longitudinal vein (the anal), with numerous obliquely longitudinal, simple branches; on the right wing, however, it would appear as if these branches, holding much the same position, were about equally divided between an anal and an internomedian set, in both of which they appear to be forked as often as simple; the arrangement faintly indicated on the right wing, corresponds better, although not closely, to that of the front wing. Goldenberg considers all the veins as belonging to the anal field, which he describes as having "many delicate, radiating, longitudinal veins, connected by scarcely perceptible delicate cross veins." Length, 11 mm.; breadth, 4 mm.

This insect is, perhaps, the most complete of any of the palaeozoic species of cockroach, the abdomen being almost completely preserved, but the legs unfortunately wanting. The pronotal shield is shaped somewhat as in *Etobl. carbonaria*, being longitudinally oval, broadest near the posterior margin, tapering toward the rounded front, the hind margin apparently broadly rounded; it is somewhat gibbous, and shows in the middle and laterally weak longitudinal furrows; it is 7 mm. long, and 6.25 mm. broad. The mesothorax is very short and inconspicuous; the metathorax quadrilateral, nearly as long as broad, broadest in front, and narrowing rapidly behind; the front and hind borders are slightly arcuate, the curve opening posteriorly, the lateral angles rounded, the surface marked by weak median, longitudinal and transverse furrows; length, 2.75 mm., breadth behind, 2 mm. The abdomen is extraordinarily slender, as it is in no modern types, giving the insect a remarkably strange aspect; seven segments are preserved, and these grow gradually larger and broader posteriorly; they are sharply separated from each other, and the lateral margins somewhat upturned; the whole abdomen is 8.5 mm. long; its breadth at base is 1.6 mm.; at the end of the seventh segment 2.2 mm.

Goldenberg remarks of this insect, that it is by far the most complete and best preserved of all that have yet been found in the carboniferous formation (*Anthracobl. sopita* was not then known); and that it presents so many anomalies in not unimportant parts of its structure, separating it from all hitherto known cockroaches, whether living or fossil, as to render it highly probable that it should be considered a peculiar extinct genus, either belonging to the family of cockroaches, or falling very near it.

So little, however, is yet known of parts other than the wings in this genus, and as the wings *appear* by their neuration to fall within this genus, it has seemed the best way to place it here, at least until new examination shall give us a better clue to its true affinities. Should the neuration prove clearly distinct from the other members of this genus, there can be no doubt that it should stand by itself.

The single specimen found was discovered in a bluish shale, in the Skalley-shaft of the Hirschbach coal-pit at Saarbrücken, Germany. Middle carboniferous.

Archimylacris (ἀρχή, μυλακρίς)

Archimylacris Scudd., Daws. Acad. Geol., 2d ed., 388 (1868).

The mediastinal vein of the front wing runs parallel to and not distant from the costal margin to a little beyond the middle of the wing, occupying less than one-fourth the breadth of the wing, and emitting a considerable number of mostly forked, very oblique, but still short branches. The scapular vein is considerably and pretty regularly curved, in the same sense as the costal margin, but rather more strongly than it, lies rather distant from the mediastinal vein, and, beginning to branch at some distance before the middle of the wing, occupies with its branches, in the apical half of the wing, an average of nearly or quite one-half the breadth of the wing; its trend, however, is so far downward that, traversing the apex of the wing obliquely, it terminates below the tip; it emits a large number of branches, the general direction of which is similar to those of the mediastinal vein; they fork repeatedly, so that the area is closely crowded with veins. The externomedian area is insignificant: the vein runs parallel to the preceding, forks a little way beyond it, the branches again bifurcating once or twice, all in a longitudinal way and closely approximated, so that at the extremity of the inner margin the area only covers a very limited space. The anal and internomedian areas together cover almost the entire inner margin, are very broad opposite the middle of the former, where they occupy considerably more than half the breadth of the wing, and rapidly and regularly diminish in width; the anal furrow is very strongly arcuate, rather distinctly impressed, and terminates at or a little beyond the end of the first third of the inner margin; there are six or seven simple or forked branches of the internomedian vein, nearly all of which curve a little outward as they approach the margin, and are more longitudinal toward the apex than toward the base. The veins of the anal area are five or six in number, more frequent toward the anal angle, nearly straight and oblique, and simple; excepting that next the anal furrow, which is arcuate, and emits two or three inferior branches, nearly parallel to the other veins.

The wings are peculiar for the backward sweep of the scapular vein, so that the entire apex is included in the area of this vein; the two species differ very much in the proportion of the length to the breadth, one being remarkably stout, the other a little more than usually slender.

Besides front wings, one of the species referred to this genus, preserves a fragment of the hind wing, and a pronotal shield; the former consists of the extremity of the costal margin, and simply shows a collection of closely crowded, forked veins, having a somewhat oblique direction, so nearly resembling those of the corresponding portion of the upper wing, by the broken tip of which they lie, as to appear at first sight as a continuation of them: the pronotal shield is attached to the wing, and is very regularly rounded, scarcely exhibiting the least angulation, somewhat broader than long, with a central circular depression.

This genus differs from Etoblattina in the character of the scapular vein and area, and in the narrow limits of the externomedian area; from Anthracoblattina, Gerablattina, Hermatoblattina, in the brevity of the mediastinal area, and the much greater development of the scapular area; from Progonoblattina in the very different distribution of the branches of the scapular vein, and the far greater extent of the internomedian area; from Oryctoblattina in the character or position of every area in the wing; and from Petroblattina in the distribution of the veins of the internomedian area and its slight importance.

The genus is confined to America, and is the only one of this group which has no European representatives.

Archimylacris acadicum. Pl. 6, figs. 8, 14.

Archimylacris acadicus Scudd., Daws. Acad. Geol., 2d ed., 388, fig. 153; — Ib., Amer. Nat., I, 630, pl. 16, fig. 2; — Ib., Geol. Mag., v, 177.

Fore wing. The shape of the wing cannot be definitely determined from its imperfection: the costal margin, however, is very regularly and strongly convex, and all the veins are arcuate, arising apparently from about the middle of the wing. The mediastinal vein is subparallel to the costal margin, but a little less arcuate than it, probably occupies about one-fourth its width, and terminates at about the end of the middle fifth of the wing; it emits a large number of oblique, generally forked, straight, and nearly parallel branches. The scapular vein is very strongly arcuate, parallel almost throughout to the costal margin, terminating beyond the apex; it is rather distant from the mediastinal and externomedian veins until it begins to divide, at about the middle of the wing; here, and a little further on, it sends forth a couple of compound branches, besides a short, apical, simple shoot; the earlier forks of the compound branches have a direction similar to the mediastinal veins, while the later are longitudinal. The externomedian vein follows closely parallel to the scapular vein, and emits only two branches, superior, simple, and nearly straight, near together, and only a little way beyond the branching of the scapular vein; consequently this area occupies only a narrow space at the extremity of the inner border; somewhat before the middle of the wing this vein is connected with those on either side of it by a pair of short, oblique, cross veins, having the same direction as the internomedian branches. The internomedian vein is even more strongly arcuate than the preceding, and very regularly curved; in the part which is preserved, and beyond the basal fourth, it emits four equidistant, nearly straight, parallel and oblique, simple branches (they are represented as too sinuous in the plate), and there are probably several others in the apical portion. The anal furrow is not deeply impressed, is very strongly and regularly arcuate, and probably terminates a little before the middle of the wing; there are half a dozen anal branches, mostly simple and oblique, and straight or arcuate, those next the furrow about as widely separated as the internomedian branches, the others more closely crowded.

The insect is of medium size, the wing being 23 mm. long, and the breadth of the fragment 10 mm.; probably the entire width of the middle of the wing, where it was presumably the widest, was 11.5 mm. and the breadth to the length as 1 : 2. The specimen is not very perfect, being partially overlaid by the frond of a fern, by which the lower apical half is obscured, excepting most of the longitudinal branches of the scapular and externomedian veins; the extreme base is also broken; if the upper surface is that exposed, it is a right wing; all the interspaces of the wing, excepting in the mediastinal area, are traversed by delicate cross veins closely approximated. The shape of the wing at once separates this species from *Arch. parallelum*.

The single specimen known was found by Mr. James Barnes, at the East River of Pictou, Nova Scotia, in shale overlying the roof of the main seam of Pictou coal. I owe an opportunity of examining it to Principal Dawson. Middle coal formation.

Archimylacris parallelum nov. sp. Pl. 6, fig. 6.

The fore wing is very equal, the larger part of both costal and inner margins being straight and very nearly parallel, the wing tapering only in a very slight degree until near the tip; the anal angle is broadly rounded, and very similar in this respect to the humeral lobe; the extremity of the wing is broken, so that the form of the wing cannot be stated; the veins originate a little above the middle of the base, and curve upward as they pass outward. The mediastinal vein runs subparallel to the costal margin, but gradually approaches it throughout (hardly so represented on the plate), until about the middle of the wing, when it curves rather rapidly to the border, terminating at some distance beyond the middle; it occupies less than a fourth the breadth of the wing, and emits, mostly in its outer half, five or six oblique, forked, or simple branches. The scapular vein, beyond its strong basal curve, is straight, subparallel to, but a little divergent from, the costal margin, and terminates beyond the apex of the wing; it commences to divide a little beyond the basal quarter of the wing, and emits about seven longitudinal branches at subequidistant intervals; the first is compound, beginning to branch next the apical curve of the mediastinal vein; the others are simple or forked, or rarely doubly forked, and fill the apex and apical third of the costal margin with straight, crowded veins. The externomedian vein, beyond its basal curve, runs parallel to the preceding throughout, but before it forks, in the centre of the wing, is rather distant from both the scapular and internomedian veins; it emits three inferior branches, distant at their bases, the first two doubly forked, the last simple, the branches all closely crowded, as in the preceding area, and occupying rather less than the apical fifth of the inner margin. The internomedian vein, beyond its basal curve, is straight, only curving downward a little at the extremity, which reaches the border only just before the apical sixth of the wing; it commences to branch before the end of the basal fourth, and emits about seven branches, simple or forked, the basal ones transverse, oblique, and sinuous, the apical longitudinal, oblique, and nearly straight. The anal furrow is very deeply impressed and strongly arcuate, terminating before the basal third of the wing; the first of the anal veins is nearly as arcuate as the furrow, more distant from it basally than apically, and has a couple of branches; the others are generally simple, oblique, nearly straight, and crowded.

The insect is of medium size, the wing measuring, as preserved, 23 mm. in length, and 9.5 mm. in breadth; the entire length was probably 26 mm., and the breadth to the length as 1 : 2.74; only the tip of the wing is wanting, with the apical third of the costal margin. It is the upper surface of a right wing. The anal area, especially next to the furrow, is rather tumid, rendering the depth of the furrow much more apparent; on the contrary, there is a depression in the central parts of the humeral lobe; excepting the anal furrow, the mediastinal vein is more distinctly impressed than any; the branches of this vein, and those of the two following veins, as well as the veins themselves, are rather obscurely impressed, while the veins and branches of the internomedian and anal areas are delicately raised like tracery; the surface is very flat, and the whole is covered with an obscure network of polygonal cells of raised lines, which become more distinct in the anal and mediastinal areas, where they are mostly changed to transverse lines, frequently forking in passing from one vein to another, or uniting with the neighboring cross vein.

Hind wing. A fracture of the front wing, beyond the middle of the costal margin, with the removal of the parts beyond it, leaves exposed a fragment of the corresponding portion of the underlying right hind wing. Indeed, as I have proved by experiment, the upper wing may be peeled off from the lower; the piece broken off, carbonaceous in appearance throughout, represents not only the upper wing, but the film of detritus which lay between the two wings after deposition; for it shows upon the one side (the under) sharply raised, delicate lines, corresponding exactly in reverse to the sharply impressed veins of the under wing; while upon the upper surface are faintly impressed lines which are not opposite those on the other surface of the lamina, but represent the veins of the upper wing. The fragment of the hind wing thus exposed is very small, and covers the outer half or third of the costal border. The veins have the closest resemblance to those of the front wing, beyond which they lie, and almost appear as their continuation; the veins represented on Plate 6, fig. 6, above the mark separating, for the front wing, the mediastinal and scapular areas, together with the vein next below it, are delicately raised, and probably represent the apical branches of the mediastinal vein of the lower wing, while all the others are distinctly impressed, and probably belong to the scapular vein. The former vein can be traced (but is not represented on the plate) for a short distance, through the thickness of the upper wing, running in a straight line toward the middle of that portion of the base of the wing which is covered by the prothorax.

Attached to the front wing is the pronotal shield, this being the only American fossil cockroach in which this part is certainly known. It is of a very broadly and transversely elliptical form, but, as preserved, does not have a perfectly regular outline, the curve of the left side being uniform, while that of the right side would place the broadest part of the shield a little behind the middle; with this exception it is extremely regular, either lateral or antero-posterior half being like its opposite. The surface is nearly flat and shows a centrally disposed circular or elliptical furrow, irregularly subparallel to the margin, enclosing a slightly convex central area, whose diameter is a little more than a third the breadth of the pronotum; the furrow is coarse and rather deeply impressed, but irregular from the irregularities of the stone; the posterior third of the shield is marked with faint, very closely crowded, minute, straight, transverse wrinkles, crossing the whole pronotum. Length, 7.5 mm.; breadth, 10 mm.

The parallel-sided front wing can by no possibility be confounded with that of *Archim. acadicum*, with its strongly convex costal margin; in this species the strongest part of the curve of the veins is close to the base, as in most palaeozoic cockroaches; but in *Archim. acadicum* it is at the middle of the wing, in conformity with its strong costal curve.

The single specimen was obtained by Mr. I. F. Mansfield, at Cannelton, Beaver county, Penn., in dark, sandy shale, immediately under the vein of Cannel coal referred to vein C of Professor Lesley. Lower coal-measures of Pennsylvania.

Anthracoblattina nov. gen. (ἄνθραξ, Blattina).

Blattina Auct (pars).

The mediastinal vein of the front wing runs parallel to and generally rather distant from the costal margin, terminating generally beyond, occasionally at the middle of the apical half of the wing, and emits a large number of oblique, parallel, seldom forking branches; the area generally occupies nearly one-third of the breadth of the wing. The scapular vein, sometimes curved near the base, is beyond that nearly straight, and terminates shortly before or at the apex of the wing, — in a single instance (*A. winteriana*) beyond it; it never branches more than once, usually not at all, before the middle of the wing, and the branches are usually longitudinal in appearance, although in all instances actually superior, and seldom assume the appearance of similarity to those of the mediastinal vein, as in Etoblattina; the branches are not numerous (more numerous in *A. spectabilis* than in the others), and seldom fork more than once; owing to the length of the mediastinal area, the space occupied by this vein and its branches is very restricted, although not more so than that occupied by the next vein. For the externomedian vein, which is separated from the preceding by an equal interspace, on either side of which the branches of the two areas diverge at equal angles, is usually a close counterpart in a reverse sense of the scapular vein, excepting that the first off-shoot is usually more important than the others, often equalling, with its forks, the rest of the vein. The combined internomedian and anal areas occupy fully half the breadth of the wing near the base, and, excepting in

A. dresdensis, diminish in breadth more gradually than usual, the internomedian vein passing in a very gentle curve or a nearly straight line to a point on the inner margin usually beyond that to which the mediastinal vein reaches on the opposite border; it emits a large number (in *A. dresdensis* a small number) of either simple or forked, nearly straight veins, of about the same obliquity as those of the mediastinal area. The anal furrow appears to be tolerably well impressed, is rather strongly curved, and usually terminates a little more than one-third down the inner margin of the wing; the anal veins, about half a dozen in number, have a somewhat similar though slighter curve, are nearly parallel, some or all of them simple.

The wings are stouter than usual, only one of them coming up to the average of the whole group of Blattinariae, the average proportion of the breadth to the length in the genus being as 1 to 2.4.

Only one of the species of this genus shows anything besides the front wing; this single species is unusually perfect, showing the whole body and the legs as well as both pairs of wings. The body is very slender, but almost equally so, the abdomen being as wide as the rest, but much slenderer than is usual in modern types. The thoracic shield is longitudinally oval, and the legs are similar to those of modern types; whether or not they are spinous does not appear.

This genus is most nearly allied to Etoblattina, from which it differs principally in the greater size and much greater length of the medastinal area, and the lesser extent of the scapular area; from Archimylacris it is similarly separated, although in one species (*A. winteriana*) the termination of the scapular area is somewhat similar, owing to the peculiar conformity of the tip; from Gerablattina it differs in having the branches of the externomedian vein inferior instead of superior; and from Hermatoblattina in having those of the scapular vein superior and not inferior; from Progonoblattina it differs in the much more restricted extent of both the scapular and externomedian areas; from Oryctoblattina in the far less importance and very different nature of the scapular vein, and by the very different character of nearly all the other veins; and from Petroblattina in the nature and distribution of the veins in the externomedian area.

The species of this genus are altogether confined to Europe, so far as yet known.

Anthracoblattina spectabilis. Pl. 2, fig. 8.

Blattina spectabilis Gold., Neues Jahrb. f. Mineral., 1869, 161–62, taf. 3, figs. 7, 7^a, 7^b; — Ib., Faun. saraep. foss., ii. 19; — ? E. Gein., Neues Jahrb. f. Mineral., 1875, 6; — ? Ib., Neue Aufschl. Dyas v. Weiss., 6.

Fore wing. Although the only described specimen of this species is very imperfect, its form is to a great extent known, excepting toward the base; the costal margin is regularly and strongly arcuate, while the inner margin is straight; and as the wing tapers rather rapidly in its outer half, the middle of the well-rounded tip is thrown considerably to one side of the middle line of the wing. The mediastinal vein runs parallel to the costal margin nearly as far as the middle of the wing, when it curves somewhat rapidly toward the margin and terminates at about the end of its middle third; the width of the area is about one-fourth that of the wing, and it is filled with numerous, rather crowded, simple or forked, oblique, straight branches. The scapular vein also runs parallel to the costal margin, and terminates on the apical margin just above the tip, and, being very straight in the apical half of the wing, approaches the costal margin very gradually; it commences to divide before the middle of the wing, and emits at equidistant intervals half a dozen, simple or forked, straight and nearly longitudinal branches. The externomedian follows the course of the scapular vein, and begins to branch at the same point, emitting at unequal intervals four branches, which, with their offshoots, occupy the apex and very extremity of the inner margin of the wing; the first and last of these branches in the specimen described are compound, the others simple. The internomedian vein is gently and regularly arcuate, and emits, in the middle third of the wing, half a dozen branches, the basal ones of which are compound, the apical simple, and all nearly straight or slightly arcuate. The anal furrow is roundly bent where it parts from the other veins, and beyond that straight, probably terminating a little before the middle of the wing.

This insect is the largest of the palaeozoic cockroaches, the fragment measuring 43 mm. in length and 22 mm. in breadth; the probable length of the whole wing was about 54 mm., or the breadth to the length as 1 : 2.45. Goldenberg describes the surface as covered with a network of reticulations visible to the naked eye, which near the apex of the wing are formed of transverse, closely approximated, parallel cross-veins, broken into square cells by other fine lines; while at the base and in the middle of the wing they form an irregular tetragonal or pentagonal network.

This fine species has no rival in the genus excepting the next to be described, than which it is only a little larger. It differs from this, however, in the shape of the wing, which is much slenderer and has a less convex costal margin; it also has a proportionately shorter mediastinal area; from its size, it can by no possibility be confounded with any other species of the genus. Goldenberg compares it with *Etobl. didyma*, from which, as we have seen, it is generically distinct by the inferior origin of the externomedian veins; but, as he rightly says, it differs from that species in the distribution of the branches of each of the principal veins. Besides being peculiar for its great size, this species is marked by the crowded venation and by the comparatively conspicuous reticulation.

The specimen described came from Löbejün, Germany. Upper carboniferous. Geinitz reports the discovery of a specimen at Weissig, Saxony. Lower Dyas; but as he appends to it a query, it may be considered dubious until direct proof is given.

Anthracoblattina sopita. Pl. 4, fig. 8.

Blattina didyma E. Gein., Neues Jahrb. f. Mineral, 1875, 4–5, taf. 1, fig. 1; — Ib., Neue Aufschl. Dyas v. Weiss., 4–5, taf. 1, fig. 1. Not *Bl. didyma* Germ., for which see *Etobl. didyma*.

The fore wing is rather elongated, obovate, the costal border very strongly and regularly arched, the basal two-thirds of the inner margin almost straight, the tip well rounded; it is broadest in the middle, and narrows almost equally toward both extremities; the humeral lobe is greatly produced at the extreme base, by its sudden deflection to the root of the wing, forming a rounded subacute angle; the veins originate rather below the middle line of the wing, and curve strongly upward, following very closely the basal curve of the costal margin. The mediastinal vein runs parallel to the margin over nearly two-thirds of the wing, and then curving toward it, terminates rather beyond the middle of the outer half of the wing; it emits a large number, a dozen or more, of simple or forked, oblique, and considerably arcuate branches, tolerably distant from one another; the area occupies nearly one-quarter the breadth of the wing in the middle. The scapular vein is differently represented in the two wings (of the same individual) figured by Geinitz; so differently indeed that both can hardly be correct, and for our description we have chosen the one which accords with the structure of the species evidently allied to this; in this it runs at first parallel to the costal border, as far as a little beyond the middle of the basal half of the wing, where it forks; its first branch is simple and continues in close proximity and parallel to the mediastinal vein, while it itself runs in a nearly straight, longitudinal course, terminating just before the extreme tip of the wing; it emits three other simple branches, the last one forking at the extreme tip, just beside an additional short apical branch of the main stem. The externomedian vein, more strongly arcuate next the base, divides a very little beyond the division of the preceding, and then runs parallel to that, emitting in all four branches, the first forking in the middle, the others simple; and all longitudinal, closely crowded, and together occupying an extremely narrow area on the margin at the extreme apex of the wing. The internomedian vein runs parallel to the preceding vein and its basal branch; but somewhat beyond the middle of the wing, emits a supplemental superior branch running nearly parallel to the main stem, and extending the area so much further out, that it terminates as near the apex as the scapular area, and narrows very gradually; commencing before the middle of the basal half of the wing it emits about eight nearly straight, slightly sinuous, oblique branches, the basal ones simply or doubly forked, the others simple, four or five of them emitted before the supplemental vein, the others beyond. Geinitz states, what his illustration bears out, that the second branch on this wing is forked only at the end; while in the opposite wing it is not only distinctly forked near the base ("nahe der Wurzel," but really at the end of its basal third), but one of the forks again divides at the tip. The anal furrow is rather deeply impressed on the arcuate basal half, lightly on the straighter apical portion, and terminates at about the end of the second fifth of the wing; the anal veins are arcuate, those next the furrow compound, the others simple, and all considerably and equally crowded.

Here again Dr. Geinitz's illustration is at fault, the two wings differing considerably, the anal area being undoubtedly too extended in the wing which we have not copied. Care seems to have been taken only with the wing which does not overlie the body; this is altogether unfortunate in illustrating an insect which is undoubtedly the most perfect example of a palaeozoic cockroach which has yet been found; and the chance to observe the differences between the two wings, as a basis for a distinction between individual and specific differences, is lost, excepting in the points actually specified by Geinitz; and as he particularly remarks upon the value of the differences observed by him, it is the more probable that the other differences, apparent on his plate, do not actually exist, for if they do they are of much greater importance than those he specifies.

The wing figured is a very large one, measuring 45 mm. in length, as stated by Geinitz (in his plate it is 46.5 mm. long), and 20.5 mm. broad; this he says is shorter than it should be, the wing being contracted by a transverse wrinkling of the specimen, represented in his plate by some wavy, transverse, narrow bands; the other wing is 50 mm. long and 20 mm. broad, and represents, he thinks, the proper size; it is not impossible, however, that the wings may have actually varied a little in length, and the breadth to the length may be put down as between 1 : 2.2 and 1 : 2.5. Both wings are nearly perfect, the apical edge of each being lost for a little way, and a few of the veins being obscured. The wing we have chosen for illustration and principal description, as probably delineated with greater accuracy, is a left wing exhibiting the upper surface.

Hind wing. Portions of both hind wings are preserved in connection with the fore wings, but show no outline of their form, but only some branching veins; which from their close resemblance to the scapular and externomedian veins of the front wing, as to the mode and position of their forks, probably belong to these veins; their branching appears to be a little further from the base than in the front wing.

The single specimen known, is, with the possible exception of *Etobl. insignis*, the most perfectly preserved of all palaeozoic cockroaches; for, besides the wings, we have the head, thorax, a part of the body and the legs. It is, therefore, to be hoped that Dr Geinitz will give a fuller account of it at an early period. The abdomen is probably ill preserved, as it is not represented on the plate, but is said by Geinitz to be 10 mm. long, and about 10 mm. broad, the narrowness of which he remarks. Of the head he makes no special mention; it projects a little beyond the thorax as a transversely oval body, 2 mm. long, and 5 mm. broad. The pronotal shield is longitudinally oval, broadest apparently in front of the middle, its front border well rounded, the sides convex, and the hind border apparently rather straighter than the front, its length 15 mm., and its breadth 10 mm. The two hinder pair of legs are well preserved, apparently shaped much as in modern types; no mention is made of spines; the legs are short, particularly the hind pair, where the whole leg is about 35 mm. long, the femora and tarsi of about equal length, while the tibiae are a little longer; measuring his figure, we have the length of the former, 12 mm.; its breadth, 3 mm.; length of tibia, 14 mm.; its breadth, 2 mm.; length of tarsi, 10.5 mm.; their breadth, 1.25 mm.

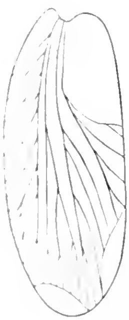
The wing is larger than in any other European species, excepting *Anthr. spectabilis*, from which it is readily distinguished by the more arched costal margin, the longer mediastinal area, and the earlier division of the scapular vein. It is related to *Anthr. porrecta* by the extent of the mediastinal area, but the distribution of the branches and the extent of the other areas differ considerably. Geinitz considers it identical with *Etoblatt. didyma* with which he says it closely agrees, specifying, indeed, the illustration of Germar copied in our Pl. 2, fig. 13. He mentions, however, certain differences, such as the greater simplicity and number of the anal veins. But there are much more important differences than these, and such as leave no doubt whatever of the specific, not to say generic, distinction, although there is unquestionably a general resemblance between the two. The shape of the wing is very different from that of *Etobl. didyma*, principally on account of the greater convexity of the costal margin in *Anth. sopita* and the greater median breadth of the wing, as compared with the extremities; in *A. sopita* again the mediastinal area is considerably longer, the scapular area very much narrower, as compared to the breadth of the wing, and its branches longitudinal, instead of oblique, and similar to those of the mediastinal area; the distribution of the veins of the externomedian area is totally different, the branches being mostly simple and inferior in *Anthr. sopita*, while the branches are superior and the uppermost unusually compound in *Etobl. didyma*, and all together cover an extensive area at the apex of the wing, instead of a very narrow one as in *Anthr. sopita*. No differences of importance exist in the internomedian and anal areas.

The single specimen comes from Weissig, Saxony. Lower Dyas.

Anthracoblattina dresdensis. (See figure in text.)

Blattina dresdensis Gein.-Deichm., Sitzungsb. naturw. Gesellsch. Isis, 1879, 12–13, figs.

The fore wing is elliptical and very regularly formed, broadest in the middle; the costal margin is pretty strongly convex, especially on the basal half; the inner margin much straighter, and the tip well rounded. The veins originate a little above the middle of the wing, and curve gently upward before assuming a longitudinal course. The mediastinal vein, beyond the basal fifth of the wing, is nearly straight, scarcely curving upward with a broad sweep apically, and terminating only a little before the apex of the wing; it emits eight or nine rather closely crowded, nearly straight, oblique branches, about half of which are simple, the others simply or doubly forked at or beyond the middle; the area is broadest a little before the middle of the wing, where it is one-third the width of the wing. The scapular vein runs parallel and close to the mediastinal until it forks, a little beyond the end of the basal third of the wing, and then turns downward in a nearly straight course subparallel to the costal margin, to just below the tip of the wing; it emits three equidistant longitudinal branches, the first two of which fork near the origin of the simple third, and embrace between them the upper tip of the wing. The externomedian vein, beyond its curved base, runs in an almost perfectly straight line to just below the extreme tip of the wing, and, commencing to branch just before the middle of the wing, or scarcely beyond the division of the scapular vein, it emits four simple, inequidistant, arcuate branches, which (especially the basal pair) are at first oblique and then longitudinal. The internomedian vein is broadly sinuous in its course, being at first convex in the same sense as the costal margins, afterwards, on parting from the anal furrow, in the opposite sense, and terminates scarcely before the middle of the outer half of the wing; the area then diminishes rapidly in size, and is occupied by only three or four straight, oblique, distant branches, none of which are long, and which become continually shorter apically. The anal area is lost, as well as most of the anal furrow, which apparently terminates not far from the end of the basal third of the wing.



Anthracoblattina dresdensis.

The length of the wing is 28 mm.; its breadth 11 mm., and its breadth to its length as 1 : 2.5. It was therefore somewhat smaller than the average of the genus. The fragment probably represents the upper surface of the left wing, and is nearly perfect, the tip being broken in two places, and the entire anal area absent; the interspaces are filled with a well-preserved reticulation of polyhedral cells. Geinitz compares this species with *Etobl. euglyptica*, and, although he mentions *Anthracobl. porrecta*, fails to see how much more closely it resembles the latter species. Besides the differences he points out in his comparison with the former, the stouter form of the wing and the inferior origin of the externomedian branches should be mentioned. Of the species of Anthracoblattina, it most nearly resembles *A. porrecta*, but differs from it in being less parallel-sided, in the unequal width of the mediastinal area, the frequent forking of the mediastinal branches, and especially in the more simple and regular branching of the scapular and externomedian veins; besides these points, the scapular-externomedian interspace strikes the margin below and not at the apex, and the internomedian branches are more distant. It is also somewhat closely allied to the much larger *Anthracobl. sopita*, from which it differs principally in the unequal width of the mediastinal area, and the form and infrequent branches of the internomedian area. In the form of the latter area, indeed, it differs from all other species of the genus, the course of the internomedian vein in all the others being broadly and somewhat uniformly arched, while in this it is rather strongly sinuous or sigmoid, and has an unusually small number of branches.

The single specimen known was found in the rubbish at the mouth of the Kaiserschacht, near Klein-Opitz, in Saxony, and, according to Geinitz, is the oldest insect known from the rocks of Saxony. Upper carboniferous.

[The publication of this species was known to me, by the kind communication of Dr. Geinitz, only after the plates were engraved and the printing of the text well advanced. I have, however, been able to place the species in its proper position in the text, to add a wood-cut, and even to alter all references to the genus where necessary.]

Anthracoblattina porrecta. Pl. 4, fig. 5.

Blattina porrecta E. Gein., Neues Jahrb. f. Mineral. 1875, 6, taf. 1, fig. 4; — Ib., Neue Aufschl. Dyas v. Weiss., 6, taf. 1, fig. 4; — Gold., Faun. saraep. foss., ii, 20.

Fore wing. The wing is long and narrow, subequal, the costal border strongly arcuate at the base, but beyond very gently convex to the rather broad, well-rounded tip; the inner margin is broken, but probably nearly straight; the veins originate at about the middle of the base, and curve gently upward before becoming longitudinal. The mediastinal vein follows very closely the costal margin, but at considerable distance, approaching it very gradually in the apical half of the wing, and terminating only just before the apical sixth of the wing; it emits nine or ten oblique, straight, generally simple veins, and occupies about one-third the breadth of the wing. The scapular vein has a regular, gently and and broadly sinuous curve, runs subparallel to the costal margin, and terminates at the tip of the same; it breaks into two shoots just before the middle of the wing, the lower of which emits two apical, superior, simple branches; the upper, at subequidistant intervals, three straight, superior branches, the basal forked, the others simple, similar in direction and appearance to the apical branches of the mediastinal area. The externomedian vein runs closely parallel to the preceding, and emits two inferior branches, one at the point where the scapular vein divides, which is doubly forked, and the other nearly half way to the margin, which is probably singly forked. The internomedian vein is regularly and rather gently arcuate, and terminates on the inner margin a little before the extremity of the mediastinal vein, and emits four long and very gently arcuate, simple branches at regular intervals from the middle of the basal half of the wing. The anal furrow is distinct, very regularly and broadly arcuate, terminating scarcely before the middle of the wing; the anal veins are simple, arcuate, and apparently distant.

The wing is a large one, measuring 34 mm. in length, and 12.5 mm. in breadth, the breath being to the length as 1 : 2.7. The only example known is nearly perfect, and if the upper surface is exposed, represents a left wing, whose inner margin is nowhere well defined, the anal field obscured, and an unimportant fragment of the tip missing. As Geinitz says, it is clearly distinct from any other species, and is peculiar for the reversed similarity of the scapular and externomedian veins, which occupy equal spaces on either side of the extreme apex. It is much smaller than the preceding species, from which it also differs in form, in the width of the mediastinal area, and the very different distribution of the scapular and externomedian branches. It probably agrees better in size with *Anthr. Rueckerti*, from which it is abundantly distinct by the much earlier division of the scapular and externomedian veins. From the succeeding species, *Anthr. winteriana*, it differs strikingly in the greater width of the mediastinal area, and in the distribution of the branches of the externomedian veins.

The single specimen was found in the coal shales of Weissig, near Pillnitz, Saxony. Lower Dyas.

Anthracoblattina winteriana. Pl. 4, fig. 12.

Blattina winteriana Gold., Neues Jahrb. f. Mineral, 1870, 288–89, figs. 1–4; — Ib., Faun. saraep. foss., ii, 19, 25–26, 51, taf. 1, fig. 11.

Fore wing. The basal third or thereabouts of the wing being broken, its shape cannot be fully described, but in the parts which are preserved are some unique peculiarities; the costal margin, straight in the middle of the wing, is afterwards strongly curved, and meets the almost equally curved inner margin at nearly a right angle, the tip being bluntly angulated, an extremely rare occurrence in palaeozoic cockroaches. The mediastinal vein is nearly straight, in near proximity to the costal margin, and when the latter begins to curve toward the apex, this curves in an opposite direction, giving the mediastinal area an elongated lancet-shaped form; the vein terminates at some distance before the apex, probably scarcely before the apical sixth of the wing, and emits a considerable number of rather distant, straight, simple or forked, oblique branches, becoming more longitudinal toward the tip; the area is probably not more than a sixth of the width of the wing, at the middle. The scapular vein is rather widely separated from the mediastinal, and forks probably not far from the middle of the wing, and continues then in a nearly straight line, subparallel to the costal border, and terminates below the tip of the wing, being near the apex double the greatest width of the mediastinal area; it emits, at subequidistant intervals, four straight longitudinal branches, the first compound, the second forked beyond the middle, the others simple, the ultimate branches much more closely crowded than the mediastinal branches. The externomedian vein divides close to the base of the wing, in exactly what manner cannot be said; for in the only specimen known, three very straight veins, which most probably belong to this area, appear at the basal edge of the fragment, the outer ones forking once beyond the middle of the wing, all parallel to the scapular vein, and occupying a small area near the extremity of the inner margin, shorter than that occupied at the margin by the scapular area, and, by the nearly uniform width of the area throughout the wing, forming a striking contrast to the fan-shaped disposition of the scapular branches. The internomedian vein is also parallel to the same veins, showing only a slight tendency to an arcuate course, and terminating at the same distance from the apex as the mediastinal vein; it emits four or more, rather distant, simple or forked, straight and oblique branches.

The length of the fragment is stated by Goldenberg to be about 22 mm., its breadth 13 mm.; the entire length can only be roughly conjectured; it may have been 30 mm. long, or above the medium size; its breadth was to its length probably as 1 : 2.3. Goldenberg's illustration of the natural size would, however, make the fragment only 18.5 mm. long, or his magnified drawing only 21 mm.; the enlargement on our plate chances to have been based for size upon the smallest of these figures, and is therefore doubtless too small; in length it should have closely resembled *Anthr. Ruckerti.* The fragment represents the upper surface of a left wing, in which the basal third, the whole anal field, and part of the internomedian is destroyed. The veins are all deeply impressed, and the interspaces are correspondingly vaulted, but the mediastinal vein, probably by the mode of preservation, is sharply elevated into a ridge. Goldenberg describes the cross venation as nearly effaced, but where traces of it are found, as consisting of a network of delicate quadrangular meshes, visible only by considerable enlargement.

This wing is very peculiar, not only for its pointed apex, but for its elevated mediastinal vein, perhaps due, as remarked, to accident; and also for the nearly equal breadth of its long externomedian area, which is the more striking because unaccompanied by corresponding differences in other parts. These peculiarities forbid any reference of this form to any other species, and render unnecessary any special comparison with allied types. It is placed in its present position, however, because it resembles the preceding species in the distribution of the scapular and mediastinal branches, and the following in the narrowness of the mediastinal area, more than it does the other species; but the resemblance is not very great, nor does it extend to other important parts of the wing. Goldenberg compares it to *Blattina russoma*, but only as regards the size.

The single specimen was found in the Dudweiler coal-pit, near Saarbrücken, Germany. Middle carboniferous.

Anthracoblattina Remigii. Pl. 4, fig. 2.

Blattina Remigii Dohrn, Palaeont., XVI, 133–34, taf. 8, fig. 3; — Gold., Faun. saraep. foss., ii, 20, 26–27, 51, taf. 1, fig. 13.

Fore wing. Nearly the whole of the inner margin is wanting, so that the form of the wing cannot be definitely stated: it would appear, however, to have been nearly equal or slightly tapering, for the principal veins are straight for most of their course, and the costal border is very gently and regularly convex, with the appearance of a fully-rounded apex. The veins originate from above the middle of the wing, and have only a very broad and gentle upward curve near the base. The mediastinal vein runs subparallel to the costal margin, very gradually approaching it, a little more rapidly as the apical third of the wing is entered, terminating scarcely before the apical sixth of the wing: the area is about one-fifth the breadth of the wing, and is filled with a large number (eight to ten) of arcuate, simple branches, longitudinally oblique even at the start, and becoming nearly longitudinal toward the apex. The externomedian vein is much more distant from the mediastinal than from the internomedian vein, has a very gently arcuate, longitudinal course, parallel to the costal margin in the basal two-thirds of the wing, and terminates at the very tip of the wing; it divides, a little before the middle of the wing, into two branches, each of which fork near the tip of the wing only. The externomedian vein runs in close proximity to the preceding, is straight beyond the basal fifth of the wing, is represented by Dohrn as first dividing in the apical third of the wing, and emitting two simple inferior branches; the space, however, in the apical half of the wing between the externomedian and internomedian veins is so great, that there must certainly be at least another, and that probably a forking vein, originating a little beyond the middle of the wing and occupying this space.

The internomedian vein is rather strongly and regularly arcuate throughout, and terminates probably about as far from the tip of the wing as the mediastinal vein; it emits only three similarly arcuate, long, and very distant branches. The anal furrow is not very deeply impressed, rather strongly and regularly arcuate, terminating at a little before the middle of the wing; as the veins originate above the middle of the base, even including the anal furrow, the anal area is very large; the anal veins, to the number of six or seven, are rather distant and simple, at first arcuate, afterwards nearly straight.

The wing is one of the smaller ones, the fragment measuring 14 mm. in length and 6.2 mm. in breadth, the whole wing being probably about 15.5 mm. in length, and the breadth to the length as 1 : 2.5. A large part of the lower outer portion of the wing is broken, but the course of the veins is pretty clear throughout; the upper surface of the wing, which is a left one, is exposed, on which the veins are slightly elevated; but the anal furrow is rather indistinct and depressed, the anal area being vaulted to a considerable degree, while the middle of the wing is rather concave; no cross venation can be seen.

The distant venation of the lower part of the wing, *i. e.*, in the anal and internomedian areas, is in unusual contrast to the crowded distribution of the other branches, and marks this wing as very distinct from others; so, too, the narrowness and equality of the space between the mediastinal and internomedian veins in the basal half of the wing is rather peculiar, and allies the species to the following; from which, however, it is remarkably distinct in the narrowness of the mediastinal area; in this particular, one is reminded only of the preceding species, but the distribution of all the other veins is very different. Dohrn and Goldenberg compare it to *Hermatobl. lebachensis*, with which, indeed, the general resemblance is greater than with perhaps any other palaeozoic cockroach; but besides its lesser size and the comparative narrowness and equality of the mediastinal area, we find the scapular branches superior, instead of being inferior, as in *Hermatobl. lebachensis*.

The single specimen was found in an argillaceous schist in a coal-pit on the Remigiusberge, near Cusel, in Rheinpflalz. Upper carboniferous.

Anthracoblattina Rückerti. Pl. 4, fig. 1.

Blattina Rückerti Gold., Neues Jahrb. f. Mineral., 1869, 163–64, taf. 3, fig. 11.

Fore wing. The apex of the wing only being preserved, and that not perfect, it is impossible to describe the form of the wing; the apical half of the costal border, however, is preserved, showing a curve very similar to that of the species last described. The mediastinal vein, if I have rightly interpreted it, is remarkably distant from the costal margin, so that the area must occupy more than a third of the width of the wing, terminating just before the apical sixth of the wing, and possessing distant, simple, nearly straight, and oblique branches. The scapular vein is straight or scarcely arcuate in an opposite sense to the costal margin, in the outer half of the wing, and terminates scarcely before the tip, dividing only in the apical third of the wing, and emitting at rather wide angles three simple or forked branches. The externomedian runs down the middle line of the wing exactly parallel and close to the preceding, begins to divide at the same point, and has two equally divergent, simply or doubly forked branches, occupying an exactly equivalent area to those of the scapular vein. The internomedian vein is gently arcuate in the distal half of its course, terminating a little beyond the mediastinal vein, and has a large number of straight, oblique, crowded branches, simple or deeply forked.

The length of the fragment is 16.5 mm.; its breadth, 13.5 mm.; probably the length of the wing was about 30 mm., or a little above the medium size, and the breadth to the length as 1 : 2.2. The restored parts in our plate, however, no doubt represent the wing as too broad, the projecting part of the internomedian area being inaccurately drawn. Goldenberg describes the interspaces as filled with parallel and straight cross lines. If the upper surface is exposed, the wing is a left one.

It is peculiar for the great width of the mediastinal area, even if we have carried it a single vein too far inward; and the regularly opposed and straight distribution of the branches on opposite sides of the scapular-externomedian interspace, which follows nearly the middle line of the wing, gives it a peculiar aspect. Goldenberg compares it to *Hermatobl. lebachensis*, but the different position of the scapular branches, superior instead of inferior, at once distinguishes it from that, not to mention the points referred to by him. It is more nearly allied to *Anthr. Remigii*, from which, however, it may be distinguished at a glance by the far less arcuate form and the much greater frequency of the internomedian branches.

Goldenberg neglects to record this species (of his own description) in his Catalogue of fossil cockroaches (Faun. saraep. foss., ii, 19–21.)

A single specimen, from the Max coal-pit of Stockheim, Oberfranken. Dyas.

Gerablattina nov. gen. (γέρας, Blattina).

Blattina Auct (pars).

The mediastinal vein of the front wing runs parallel or subparallel to the costal margin, and generally rather distant from it, frequently more distant in the middle of its course than elsewhere, and terminates generally beyond the middle of the apical half of the wing, frequently far toward the very apex; it sends a large, sometimes a very large, number of oblique, straight or curving, usually simple branches to the costal margin. As the division between the scapular and externomedian areas is at or before the tip of the wing (in a single species, *G. Mahri*, perhaps slightly beyond it), the scapular area is necessarily much restricted; generally speaking, it is limited to only a few apical branches, which scarcely originate before the middle of the apical half of the wing; and in one or two, such as *G. Geinitzi* and *G. Münsteri*, there is only a single apical fork; but in *G. Germari* and *G. weissiana* there are several branches, which originate near the middle of the wing; the American species, however, seem to form a distinct section; for notwithstanding that the great length of the mediastinal vein is still retained, the scapular vein begins to branch before the middle of the wing, and emits three or four branches, some of which branch again, and that more than once; the branches of this vein are always superior, whether the extent of the branching be considerable or slight. The externomedian vein is very similar to the scapular, although in some, but not all, of the species in which the scapular area is greatly reduced, it does not suffer to a corresponding extent; in the species placed at the head of the series, as well as in *G. Geinitzi* and *G. Münsteri*, it is considerably more extensive than the scapular area, but in the others, including the American species, it is very similarly developed; all the branches are likewise superior, so that the reverse obliquity of the branches of neighboring veins appears in this genus in the interspace between the externomedian and internomedian veins. The combined internomedian and anal areas occupy, in the species at the head of the series, somewhat more than half of the width of the wing at the base, about one-half or slightly more than that in the others; and it generally diminishes gradually and regularly in width, and terminates, with rare exceptions, nearer the tip than does the long mediastinal vein; in some species the internomedian vein is nearly straight; in others, however, while there is at first a rapid diminution in the breadth of the area, the vein afterwards runs parallel to the inner border, and extends the area far toward the tip of the wing; the vein has a large number of subparallel, straight or gently curving branches, which are indifferently simple or branched, and the obliquity of which corresponds in most cases very closely, although in a reverse sense, to the branches of the mediastinal vein. The anal furrow is generally pronounced, and straight or gently curved; in one or two, however, it is very arcuate, and, while somewhat irregular in termination, its tip seems never to be far removed from the end of the basal third of the wing; the anal veins, where known, are frequent, parallel, arcuate, and generally simple in the European species and in one of the American species; but in the other American species, *G. fascigera*, they are very different, being nearly straight, multiple-forked, running in a direction somewhat divergent from that of the anal furrow, and approaching the latter only near its termination.

The wings in this genus are slightly above the average in slenderness, being precisely the same, as a whole, as in Etoblattina, the breadth being contained in the length scarcely less than two and three-quarter times.

This genus appears to be most nearly allied to Hermatoblattina, from which it differs sufficiently in the superior position of the branches of the scapular vein; from Etoblattina and Archimylacris it may be separated at once by the great length of the mediastinal area; from Anthracoblattina it differs in having the branches of the externomedian vein superior and not inferior; Progonoblattina, with the wide extent and importance of its scapular and externomedian areas, is readily distinguished from it; Oryctoblattina for similar reasons, as well as for many others, cannot be confounded with it; while the strong backward curve of the externomedian vein in Petroblattina, with the extensive area covered by its longitudinal branches, separates it from that genus at a glance.

Most of the species of the genus, which next to Etoblattina is the richest in known forms, come from the old world; but two American species must be placed here, although the extensive development of the scapular vein would perhaps, as suggested above, warrant separating them as a peculiar section.

Gerablattina Goldenbergi. Pl. 3, fig. 13.

Blattina Goldenbergi Mahr, Neues Jahrb. f. Mineral., 1870, 282–84, fig. 1; — Gold., Faun. saraep. foss., ii, 19.

Fore wing. The apical third of the wing being lost, its precise form cannot be described, but it was evidently long and narrow; the costal margin is regularly and rather strongly arcuate, with a very prominent humeral lobe, the inner margin straight, with its basal angle rather broadly rounded. The veins originate much below the middle of the base and curve strongly upward over a considerable distance, so as soon to occupy the middle of the upper two-thirds of the wing. The mediastinal area is nearly one-third the width of the wing, the main vein running parallel with the costal margin for a long distance, probably over the basal two-thirds of the wing, beginning to turn toward the border only at the very extremity of the fragment, and probably reaching the border at no great distance before the tip of the wing; it emits nearly a dozen distant, nearly straight, simple and oblique branches. The scapular vein runs closely parallel to the preceding throughout the fragment, supposing the two veins which appear to originate from its under surface to represent the externomedian vein: whether this interpretation is correct, neither the description nor the illustration of Mahr enable us to state positively; but the resemblance of this wing to others of the genus in which we place it renders it probable that here, as is usually the case in the genus, the scapular is of less importance than the externomedian vein, and in such a case only one of the three veins which lie between the mediastinal and internomedian veins in the middle of the wing can belong to the scapular vein: although this vein is simple in the fragment, the turn of the mediastinal vein toward the costal border renders it nearly certain that it forks at least once or twice in the apical third of the wing. The externomedian vein, on the same assumption, divides into two branches before the middle of the wing, each of which again forks beyond the middle of the wing, and undoubtedly branches again beyond that, probably occupying upon the margin all the space from a little above the tip to the extremity of the internomedian area; the general course of the vein is at first strongly arcuate, afterwards longitudinal. The internomedian vein is strongly arched in the basal half of the wing, then becomes straight or bent a little toward a longitudinal direction, and probably terminates about as far from the tip as the mediastinal vein; it emits only three branches, the first forked, the others simple, all gently arcuate, oblique, and distant; the veins of this area are represented by exceedingly heavy lines in Mahr's illustration, but as he makes no mention of any difference between them and the others, this is probably an error. The anal furrow is very strongly arcuate indeed and deeply impressed, terminating, probably, a little before the middle of the wing; the anal veins, according to Mahr, are ten in number, but many more are represented in his figure, which is carefully followed in our plate; these are all arcuate, regular, simple, and, in striking contrast to the other areas, closely crowded.

The wing is of medium size, the length of the wing being 15.5 mm., while the entire length of the wing is probably about 23 mm.; its breadth is 9 mm., and the breadth to the length as 1 : 2.55. From Mahr's statement that the anal field is concave, the under surface is evidently exposed to view, and the wing is therefore a right one.

It is remarkable for the great extent of its anal area, by which it is readily separated from all the species of the genus in which this area is known, and for the close proximity of the veins in this area as contrasted with their wider separation in the rest of the wing; in the uniform belt-like nature of the mediastinal area it resembles several of the species, particularly *G. clathrata*, *G. intermedia*, and *G. Mahri*; from the first of these it is quickly distinguished by the distance of the branches of the mediastinal vein, in which particular it more nearly resembles the other species; from *G. Mahri* it differs greatly in size and in the convexity of the costal margin; and from *G. intermedia* in the early division of the externomedian vein and the strongly-curved internomedian vein.

A single specimen, from an argillaceous schist between the third and fourth veins of the Ilmenau coal basin, Manebach. Upper carboniferous.

Gerablattina clathrata. Pl. 3, fig. 4.

Blattina clathrata Heer. Viertelj. naturf. Gesellsch. Zürich, IX, 288, 294–96, pl., figs. 3, 3ª, 3ᵇ; — Gold., Faun. saraep. foss., ii, 19.

Fore wing. The extreme tip and most of the anal area are wanting, and the inner margin is also broken, so that the precise form is uncertain; it is, however, tolerably broad, and the costal border rather strongly and regularly arcuate, much as in the preceding species, but with a very slight humeral lobe; the principal veins are all almost similarly arcuate, originating near the middle line of the wing, and running subparallel to the costal margin; the branches on either side being very frequent, long, and straight, and, parting from their stems at an equal angle, give the wing a peculiarly simple appearance. The mediastinal vein runs nearly parallel to the costal margin, but is more distant from it in the middle than at the base of the wing, is bent at the origin of its first branch, the humeral lobe being devoid of branches, begins to approach the margin a little beyond the middle of the wing and terminates at the very end of the fragment, or probably about midway between the middle of the costal border and the extreme tip of the wing; it emits about a dozen closely-crowded, straight or nearly straight, simple or occasionally apically-forked, oblique and nearly parallel branches, the direction of the apical not diverging greatly from that of the basal branch; the area is very broad, occupying nearly one-third the breadth of the wing. The scapular vein, appearing to originate from the same stem as the externomedian and to separate from it in the middle of the basal half of the wing, runs close and parallel to the mediastinal, until that vein turns toward the costal margin; it retains thereafter its former direction for some distance, and then turns very slightly and gradually upward, and terminates just before the tip; in this apical portion it emits three closely approximated branches, the first next the last branch of the mediastinal vein, and basally forked, the others simple and soon parallel to the main stem. The externomedian vein does not fork until past the middle of the wing, and, just this portion being destroyed, it is impossible to give a precise statement, but in any case the distribution of the veins is peculiar, for the three or four straight and simple branches, which occupy the tip of the wing and run subparallel to the scapular branches, spring, in the apical fourth of the wing, from a vein which runs almost exactly parallel with the costal border, and in continuation of the main externomedian vein; while the other three or four branches, which strike the apical part of the inner margin, run parallel to the internomedian branches, and are much longer than the other externomedian branches, running parallel to each other in a straight and simple course, and originating, in some indeterminable manner, scarcely beyond the middle of the wing. The internomedian vein is rather strongly and very regularly arcuate, terminates a little nearer the apex than the mediastinal area, and emits about ten nearly straight, very long, parallel, oblique veins, the first doubly forked, the others simple; the area at its broadest occupies considerably more than half the breadth of the wing. The anal furrow is well impressed, strongly arcuate, apically nearly straight, terminating not much beyond the basal third of the wing; one or two fragments of anal veins next to the furrow are preserved, running parallel to the same.

The wing is of rather large size; one of the largest of the genus, the fragment measuring 32 mm. in length, and 13.5 mm. in breadth; the whole wing is probably 35 mm. long, according to Heer, the breadth being to the length as 1 : 2.6. By some accident it has been represented upon my plate as magnified slightly less than twice. From Heer's description of the reticulation, probably the upper surface is exposed, and the wing is that of the left side; all the interspaces, according to Heer, are filled with a very fine network, as in *Oryctobl. reticulata*, consisting of polygonal cells, forming from two to four rows in each interspace, whence the specific name.

The species is peculiar for the regular distribution of the branches, parting in a uniform manner on either side of the principal veins; and for the unusual distinction of the upper and lower branches of the externomedian vein, which take the direction, — the upper of the scapular, the lower of the internomedian branches. In the great breadth, length, and uniformity of the mediastinal area, this insect resembles several of the species of Gerablattina, but especially *G. Goldenbergi* and *G. Mahri*. In the form of the wing it most resembles the former species, from which it is readily distinguished by its larger size, the much greater extent of its internomedian and much smaller extent of its anal area. From *Gerabl. intermedia*, with which it agrees to a certain extent in the apical division of the scapular and externomedian branches, it is readily separated by the far more crowded neuration and the larger size of the wing.

The single specimen comes from the coal-measures of Manebach, in Thüringen, associated with leaves of *Pecopteris arborescens*. Upper carboniferous.

Gerablattina intermedia. Pl. 3, fig. 11.

Blattina intermedia Gold., Faun. saraep. foss., ii. 19, 21–25, 51, taf. 1, figs. 10, 10ᵃ.

Fore wing. The wing is of an obovate form, its regularity only lost by the prominence of the anal angle and the relatively diminished size of the humeral lobe; the costal border is considerably arcuate, but the humeral lobe so little developed as to be less full than the inner angle; the inner margin is gently arcuate, and the tip broad and broadly rounded; the veins originate from about the middle, perhaps above the middle, of the base, and are gently arcuate at their origin. The mediastinal vein, subparallel to and rather distant from the costal margin, turns rather rapidly toward it somewhat beyond the middle of the wing, and terminates in the middle of the outer half of the wing, emitting seven distant, arcuate, oblique, parallel, simple branches; the area occupies a little less than one-third the breadth of the wing. The scapular vein runs parallel to the costal margin until it branches in the middle of the third quarter of the wing, beyond which it curves toward the margin, and half way to it emits a second and only other branch, which is simple, the first being forked. The externomedian vein, which appears to be coalesced with the preceding in the basal fourth of the wing, runs parallel to the internomedian, and does not fork until it has reached the apical fourth, when it only emits from its upper surface two simple, short, and straight branches, which, with the main vein, occupy the tip of the wing, and leave a wide space between the scapular and externomedian veins. The internomedian vein is rather gently arcuate at the base, and beyond nearly straight, inclined downward, terminating a little before the tip of the wing, and emitting half a dozen or more distant, straight or gently arcuate, simple or apically forked, oblique branches.

The wing is of medium size, measuring 22 mm. in length and 10 mm. in breadth, the breadth to the length being as 1 : 2.2. If the upper surface is exposed, it belongs to the right side. The anal area is lost, but otherwise the wing is perfect, and in certain places, says Goldenberg, one may see with a lens a delicate polygonal reticulation in the interspaces, which he represents as formed of very closely approximated cross lines, often connected near the middle by oblique cross lines, so as to form elongated interdigitating cells.

This wing is peculiar, as Goldenberg remarks, for the very slight development of the scapular and externomedian veins, and especially for the apical division of the latter. He might also have added, its open neuration. In comparing it with "*Blattina flabellata* Germ.," Goldenberg doubtless had in mind our *Gerabl. Münsteri*, with which it no doubt agrees in general features, but is at once distinguished by the peculiar marks of the species just referred to; it is, however, more closely related to a species described by Goldenberg at the same time, *Gerabl. scaberata*, which also has very sparse neuration. It differs from this, however, in the character of the mediastinal branches, which are far more longitudinal in *Gerabl. scaberata*, and some of them also forked, while the division of the scapular and externomedian veins in that species is even simpler than here. In the apical division of these two veins just mentioned it is related to *Gerabl. clathrata*, but the smaller size and openness of the neuration at once separate it from that species.

The single specimen comes from a bluish bituminous shale at Wemmetsweiler, near Saarbrücken, Germany. Middle carboniferous.

Gerablattina scaberata. Pl. 3, fig. 3.

Blattina scaberata Gold., Faun. saraep. foss., ii, 19, 25, 51, taf. 1, fig. 8.

Fore wing. The fragment preserved is exceedingly imperfect, and all that can be said of the form of the wing is that its costal border, away from the two extremities, is nearly straight or scarcely arcuate. The neuration of the wing, however, is sufficiently preserved to indicate its probable place in this genus, and to distinguish it from the other species of the same. The mediastinaal vein runs parallel to the border in the basal third of the wing, then approaches it very gradually, terminating in the middle of the apical half; it is very distant from the margin, the area probably occupying about one-third the width of the wing; it emits half a dozen straight and very long, longitudinally oblique veins, some of the basal ones rather deeply forked, the others simple, and all distant. The scapular vein terminates just before the tip, is nearly straight from beginning to end, and probably emits only a single, and that a simple, branch at the middle of the outer half of the wing; for there is hardly space for more. The externomedian vein runs in a straight course down the middle of the wing, and can hardly fork more than once,[1] and that beyond the middle. For the internomedian vein also runs in a straight line along more than half the wing, and must terminate scarcely below the tip; only one branch of this vein can be seen, and this has an unusually longitudinal trend, like the branches of the mediastinal vein.

The wing is of tolerably large size, the length of the fragment being 25 mm.; its breadth, 7.5 mm.; the probable length of the wing is 30 mm., but its breadth can only be conjectured. The base, almost the whole of the lower half of the wing, and a large part of the tip are lost. If the upper surface is exposed, the wing is of the right side. Goldenberg mentions that no reticulation can be discovered, but that the interspaces are sprinkled with small raised points.

[1] In the plate the branch of this vein should have been given in dotted lines at the base as well as beyond.

The wing is peculiar for the longitudinal direction of the branches of the mediastinal and internomedian veins, and also for the simplicity of the scapular and externomedian branching; the latter, indeed, is only inferred, but reasonably so, from the openness of the existing neuration, the small space left for branches, and the extreme straightness of the principal veins, which is another peculiar feature of the species. It is more nearly related to the preceding species than to any other, but is readily distinguished from it by all the features above named, and by the straightness of the costal margin.

The single specimen was found in a bluish bituminous shale from the culm of the Altenwald mine, near Saarbrücken, Germany. Middle carboniferous.

Gerablattina Geinitzi. Pl. 2, fig. 11.

Blattina Geinitzi Gold., Neues Jahrb. f. Mineral., 1869, 160-61, taf. 3, fig. 5; — Ib., Faun. saraep. foss., ii, 19.

Fore wing. The wing is of peculiar form, the costal margin being straight nearly to the tip, while the inner border is rather strongly arcuate and the tip well rounded; Goldenberg considers the humeral angle as complete, and therefore states, as another point in contrast to the form of the wing in other ancient cockroaches, that it does not project so far basally as the anal angle; but this would hardly seem consistent (to the extent figured) with the use of the wing, and we are therefore forced to believe the wing imperfect. The veins originate from the middle of the upper half of the base, and do not curve upward. The mediastinal vein, owing to the straightness and basal contraction of the costal margin, is nearer the margin basally than beyond, pursuing an arcuate course, first divergent from, afterwards convergent with the margin, and terminating only a little before the apex, or at the extremity of the straight portion of the margin; the area is widest in the middle of the wing, where it is less than a fourth of the entire width of the wing, and is filled with frequent, longitudinally oblique, simple, arcuate veins, about eight in number. The scapular vein is remarkable for its excessive simplicity, following close to the mediastinal vein, and forking once only and close to the extremity, beyond the origin of the last mediastinal branch. The externomedian, on the contrary, has a broadly sinuous course through nearly the middle of the wing, and although it begins to fork before the end of the basal third, it only occupies, with its three branches, the extreme apical border of the wing; the branches are equidistant, the last emitted before the end of the middle third of the wing, superior, longitudinal, and closely crowded apically, the first one (in the only specimen known) simple, the next simply, the last doubly forked. The internomedian vein is subarcuate, or bent in a sense opposite to what is usual in palaeozoic cockroaches, the basal half being nearly straight and bent downward, the apical nearly straight and sublongitudinal, terminating just before the tip, where the scapular vein ends, and emitting about eight crowded, subarcuate, simple or forked veins, the apical much more longitudinal than the basal. The anal furrow appears to be lightly impressed, gently arcuate, terminating a little before the middle of the wing; the five anal veins are at first simple and arcuate, like the furrow, afterwards forked and straighter.

The wing is of small size, measuring 14 mm. in length and 4.75 mm. in breadth; or the breadth to the length nearly as 1 : 3. If the upper surface is exposed, the wing is from the right side. Goldenberg makes no mention of the surface characters. The wing is unusually perfect, but probably the basal portion at the humeral lobe is wanting. It is peculiar for the straightness of its costal margin as contrasted with the fullness of the inner margin, for the basal narrowing of the mediastinal field, and for the extreme apical simple forking of the scapular vein. In the first and last of these features it is undoubtedly allied to the preceding species, but is readily distinguished from that by its narrower mediastinal field, as well as by abundant division of the externomedian vein, the smaller size of the wing, and the much more crowded neuration. *Gerabl. Münsteri* has a somewhat similar scapular vein, and also has a crowded neuration, but it also has an extremely wide mediastinal field, in striking contrast to this species; its straight costal margin also at once separates this species from *Gerabl. Münsteri*, as indeed from all the other unmentioned species of this genus.

The single specimen found comes from Löbejün, Germany. Upper carboniferous.

Gerablattina Munsteri. Pl. 2, fig. 12.

Blattina flabellata Germ., Verst. Steink. Wettin, 84–85, tab. 31, fig. 5[a], 5[b]; — Gieb., Ins. Vorw., 315. Not *Bl. flabellata* Germ., Münst. Beitr. (for which see *Etobl. flabellata*).

Fore wing. The costal margin is rather strongly and regularly arcuate, while the inner margin is straight; and the wing, being broadest at the end of the basal third, tapers very regularly thereafter to the tip, which is broken, but probably well-rounded; the veins originate a little above the middle of the base, and curve a little upward at first. The mediastinal vein is arcuate at base, straight and subparallel with the costal margin beyond and past the middle of the wing, curving gently toward the margin, which it does not reach until about the middle of the apical fourth of the wing; the area is very broad, being fully two-fifths the entire breadth of the wing in the middle of the latter, and emits a large number, a dozen or more, of nearly straight, mostly simple, occasionally forked, branches, the basal ones transversely oblique, the apical longitudinally oblique. The scapular vein is very simple, broadly sinuate, follows the course of the mediastinal vein, and, passing nearly through the centre of the wing, forks once in the middle of the apical half of the wing, and occupies only an extremely narrow area on the extreme apical portion of the costal margin. The externomedian vein appears to be coalesced with the scapular in the basal fourth of the wing, but both before and after its separation follows exactly parallel and close to the internomedian vein, which terminates probably almost as near the apex as the scapular vein, leaving for the externomedian vein only the very apex of the wing; it begins to branch a little before the middle of the wing, and emits, at equidistant intervals, three longitudinal branches, the middle one arising in the middle of the wing, and simple, the others simply or doubly forked, so that the apex is crowded with veins. The internomedian vein is rather strongly arcuate at base, then runs downward in a nearly straight line toward the middle of the apical half of the inner margin, until nearly the end of the middle third of the wing, when it turns suddenly outward, and runs parallel to the inner border, doubtless afterwards approaching it, and probably terminating only when the apical margin is reached; it emits about eight straight, oblique veins, the short apical ones only slightly more longitudinal, all simple excepting one which is compound, and fills the apical part of the regular portion of the area. The anal furrow is distinctly impressed, rather gently and regularly arcuate, and terminates a little beyond the basal third of the wing; the anal veins, six in number, are simple and similarly arcuate.

The wing is somewhat below the medium size, the fragment being 17.25 mm. long and 6.5 mm. broad; probably the real length of the wing is 18.5 mm., and the breadth to the length as 1 : 2.85. The upper surface of the wing appears to be exposed, and is that of the left side. Germar speaks of the principal mediastinal and internomedian veins as delicate.

Germar confounded this species with that formerly described by him in Münster's Beiträge under the name of *Bl. flabellata*. It is indeed very close in general appearance, but if the figure given in Münster's Beiträge is correct, two species belonging to different genera are indicated. The principal difference is to be found in the upper half of the wing. In *Etobl. flabellata* (as first described, and as we have restricted it), the mediastinal area is very narrow, and the vein terminates at about the middle of the costal margin; in *Gerabl. Münsteri*, on the other hand, the area is very broad, and the vein terminates only just before the apex. In *Etobl. flabellata* again the scapular area is extensive, and filled with many veins; in *Gerabl. Münsteri*, the scapular vein is simply forked once. Or, to put it otherwise, the branches of the basal half of the mediastinal vein of *Gerabl. Munsteri* are transferred, in *Etobl. flabellata*, to another short principal vein, running above the mediastinal, and which does not exist in *Gerabl. Munsteri*; while the scapular vein of the latter, amalgamated at base with the three-branched externomedian vein, is to be considered, in *Etobl. flabellata*, as the basal branch of a four-branched externomedian vein. The close resemblance of the externomedian and internomedian areas in the two wings would have led me to consider the illustration in Münster's Beiträge as simply faulty, were it not for the following considerations: First, Germar makes no mention of any such error, but merely quotes the reference in his synonymy. Second, there are several points of difference besides those pointed out; for instance, the shape of the wing, which is less tapering in *Etobl. flabellata*, with a less arcuate costal, and a more arcuate inner margin; the compound branch of the internomedian vein, found just beyond the middle of the wing in *Gerabl. Münsteri*, is represented in *Etobl. flabellata* by a pair of forked branches, having a widely distinct origin; the simply forked vein which I have considered the scapular in *Gerabl. Münsteri* originates from the externomedian vein much nearer the base than in *Etobl. flabellata*; and the borders of the broken tip do not agree in the two wings. Third, if they are to be considered the same, the correct drawing is certainly the later one, but the structure of the mediastinal vein is circumstantially described, as well as figured, in both of Germar's works, in each case corresponding to the illustration in the same work; yet the structure of the wing of *Etobl. flabellata* is wholly in keeping with that of the genus Etoblattina, which comprises the largest proportion of the European palaeozoic cockroaches, and is indeed very closely related indeed to that of *Etobl. affinis* and *Etobl. anthracophila*, as we have already pointed out; and were it not for the remarkable similarity of the distribution of the nervures referred in *Etobl. flabellata* to the externomedian vein, it scarcely seems probable that any doubt would arise concerning the distinction of the two species. Unless Germar's original types exist, and can be verified, it seems questionable whether the point can really be decided.

Germar, in his Wettin fossils, compares this species to *Etoblattina anaglyptica*, which he says it closely resembles, so that one might take it for a small specimen of the same, but as we have seen above, the Wettin species must be placed in Gerablattina and not in Etoblattina. It is related to *Gerabl. Geinitzi* by the simple structure of the mediastinal vein, and the branching of the internomedian, but is at once distinguishable from it by the extreme breadth of the mediastinal area, and by the general shape of the wing. In the distribution of the externomedian veins it also resembles *Gerabl. producta*, but it hardly resembles it in any other feature, unless it be the shape of the wing. The structure of this same vein separates it from all the other species of the genus. Giebel plainly describes the Wettin species, and mistaking the scapular vein for the first branch of the externomedian (since they are united at the base) considers the internomedian as entirely wanting, and suggests that it should therefore form a peculiar genus.

The single specimen comes from Wettin, Germany. Upper carboniferous.

Gerablattina producta. Pl. 3, fig. 2.

Blattina euglyptica pars Gold., Neues Jahrb. f. Mineral., 1869, 162–63, taf. 3, fig. 9 (nec. 8).
Not *Bl. euglyptica* Germ. (for which see *Etobl. euglyptica*).
Compare also synonymy of *Etobl. Dohrni*.

Fore wing. The wing is rather broad and subovate, the costal margin strongly and regularly arcuate, contracted at the humeral lobe, the tip well rounded and the inner border nearly straight. The veins originate considerably above the middle of the wing, and are scarcely turned upward at the base. The mediastinal vein, however, curves upward nearly as much as usual next the base, where it is unusually near the costal margin; but beyond the base it is straight, and follows nearly parallel to the costal margin until past the middle of the wing, when it bends very slightly toward the margin, and terminates in the middle of the outer half of the wing; it emits about eight straight, oblique, mostly simple veins, and the area at its widest is scarcely one-quarter the width of the wing. The scapular vein is nearly straight from one end of the wing to the other, and terminates just above the extreme apex, separating an upper third of the wing from a lower two-thirds; commencing to divide at the middle of the wing, it emits four straight, obliquely longitudinal, superior branches, the first forked beyond its middle, the others simple. The externomedian vein is also nearly straight, but diverges a little from the preceding beyond the basal third of the wing, and terminates below the tip of the wing, and a little farther from it than the scapular vein; it commences to branch a little beyond the basal third, and emits about four straight, longitudinal, forked or simple branches at subequal distances all the way to the end. The internomedian vein is somewhat peculiar; straight, or perhaps a little arcuate at the base, it bends downward toward the lower outer angle of the wing in the second fourth of the same, and then takes a longitudinal course nearly parallel to the inner border, which it retains to the end, being throughout this portion of the wing slightly broader than the mediastinal area, or a little more than half the width of the combined internomedian and anal areas near the base; on account of the length of the apical portion of this area, I have proposed the above specific name; the vein emits about eight simple, oblique, straight, arcuate or sinuous, rather distant branches, the apical ones much more longitudinal than the basal. The anal furrow seems to be lightly impressed, rather gently and uniformly arcuate, and terminates at about the end of the middle third of the wing; the three or more anal veins are similarly arcuate, simple, and unusually distant.

The wing is of medium size, being 26.5 mm. long and 11.25 mm. broad, the breadth to the length being as 1 : 2.35. The wing is a right wing, viewed from above, exhibiting no cross venation.

Goldenberg described this insect as identical with *Etobl. Dohrnii*, and referred both to *Etobl. euglyptica*. This species, however, differs from both of them in the greater length of the mediastinal area, the later branching of the scapular vein, and the earlier branching of the externomedian vein. From *Etobl. euglyptica*, and to a lesser degree from *Etobl. Dohrnii*, it differs in the unusual form of the internomedian area, one of the characteristic marks of this species; while the wing is also much broader in proportion to its length than in those species, and differs considerably in form from *Etobl. euglyptica*. The differences between the other two species are stated in the proper place. The larger size, narrower mediastinal area, and ovate rather than tapering form, as well as the more complicated scapular vein, distinguish this species from *Gerabl. Münsteri*, to which it appears to be most nearly allied. In the narrowing of its mediastinal area at either extremity, in the character of the externomedian branches, and to a certain extent in the form of the internomedian area, it is to be compared also with *Gerabl. Geinitzi*; but it differs very much in the form of the wing as well as in the character of the scapular vein. From the species which follow it differs to such an extent in the extended production of the internomedian area, as by no means to be confounded with them.

The single specimen comes from Wettin, Germany. Upper carboniferous.

Gerablattina Germari. Pl. 3, fig. 6.

Blattina sp. Germ., Verst. Steink. Wettin, vii. 87, tab. 31, fig. 9.
Blatta Germari Gieb., Ins. Vorw., 321.
Blattina Germari Heer, Viertelj. naturf. Gesellsch. Zürich, IX. 288; — Gold., Faun. saraep. foss., ii. 19.

Fore wing. The wing is slender and tapers considerably, besides being slightly curved; the costal margin is very strongly and regularly convex, the inner margin straight or very slightly concave and a little convergent with the costal border, narrowing the rounded tip unusually; the veins apparently originate near the middle line of the wing, and curve upward a little at the base. Beyond the base the mediastinal vein runs longitudinally in a straight line to the middle of the wing, at a great distance from the costal margin, which it reaches at about the middle of the outer half of the margin; this area at its broadest occupies more than two-fifths the breadth of the wing. The scapular and externomedian veins appear to run together, and in very close proximity to the mediastinal vein, as far as the middle of the wing, and then divide, the scapular running to the apex of the wing and dividing, so that about half a dozen veins strike the costal margin. The externomedian vein, having but a narrow space to expand in, appears to emit only a single forked branch or two from near the middle of its free course, furnishing about five veins to the extremity of the inner margin. The internomedian vein, also running so close to the mediastinal in the basal half of the wing as to occupy the middle line of the wing, and crowding the middle pair of principal veins together, turns toward the inner margin more slowly than does the mediastinal toward the costal border, and, having throughout a broadly arcuate course, strikes the inner margin a little before the apical sixth of the wing; it emits four straight, oblique, simple or apically forked branches. The anal furrow is well impressed, strongly and regularly arcuate, and terminates near the middle of the wing; the anal veins that can be seen are simple, closely approximate, and similarly arcuate.

This is one of the smallest species, measuring only 11.5 mm. in length by 3.75 mm. in breadth, the breadth being to the length rather more than 1 : 3. If the upper surface is exposed, it is a left wing. Germar does not describe it, believing the neuration too imperfect for determination; but it is sufficiently preserved, to judge from his illustration (on which this description is based), to determine its generic and specific relations with a reasonable certitude. The form, excepting perhaps at the base, is well preserved, and this separates it at once from all known species. In size it agrees only with *Etobl. parvula* and *Etobl. insignis*, from which it is at once separated by the extent of the mediastinal area. The mediastinal branches are obliterated, as well as the base of those of the scapular and externomedian areas, but the extent of the mediastinal area, and the common distance from the base at which the scapular and externomedian veins divide, show that it belongs to this genus: while by the close approximation of all the principal veins in the basal half of the wing, as well as by its size and form, it is readily distinguishable from all the other species of the genus. It has no very close affinities to any of the species, although perhaps nearest to *Gerabl. Mahri*, beside which we have placed it.

One specimen, Wettin, Germany. Upper carboniferous.

Gerablattina Mahri. Pl. 3, fig. 14.

Blattina Mahri, Gold., in Mahr., Neues. Jahrb. f. Mineral, 1870, 284–85, fig. 2[a], 2[b]; —Gold. Faun. saraep. foss., ii. 19.

Compare also synonomy of *Blattina elongata*.

Fore wing very slender and somewhat tapering, the costal margin rather gently arcuate on the basal third, beyond nearly straight, the inner margin, at least in the middle, straight. The veins originate below the middle of the wing, and are strongly arcuate at the base. The mediastinal vein follows closely the curve of the costal margin, showing no tendency to approach it throughout the fragment, that is, probably, as far as the middle of the apical half of the wing; it probably terminates only just above the tip, and emits about ten straight, oblique, equal, very distant, simple branches; the area occupies nearly or quite a third of the breadth of the wing in its apical half. The scapular vein is closely parallel to the mediastinal, but very distant from it, running scarcely above the middle line of the wing; it forks once in the middle of the wing, and, to judge of the openness of the neuration, probably not again, the two forks probably enclosing the extreme tip of the wing between them. The externomedian vein is distant from the scapular vein, but not so distant as the former is from the mediastinal: beyond the base, which is lost, it is straight and longitudinal nearly to the middle of the wing; just before this it is bent rather abruptly and slightly downward, and runs nearly parallel to the internomedian vein, emitting near together, just beyond the middle of the wing, two superior, longitudinal, simple, straight branches. The internomedian vein is very gently and uniformly arcuate, and being also as distant from the externomedian as the latter from the scapular vein, the area is unusually narrow and slender, the vein probably terminating a little before the middle of the apical half of the wing; it emits half a dozen nearly straight, oblique, mostly simple, parallel, and distant branches, the second only apically forked in the specimen, and, so far as preserved, the only forked vein in the wing; the anal furrow is slight, rather gently arcuate, apically straight, terminating at the end of the basal third of the wing.

The wing is a very large one, the fragment measuring 40 mm. in length, and 15 mm. in breadth; the whole wing is probably 47 mm. long, so that the breadth is to the length as 1 : 3.1. Goldenberg estimates the length at 45 mm. The base is broken obliquely, so that the anal veins are absent, and a considerable portion of the apex is wanting, particularly next the inner margin. If the upper surface is exposed, the wing is of the left side; the veins are very prominent, and the interspaces are filled with a close, irregular net work of delicate cross veins, particularly distinct in the interspaces on either side of the first internomedian branch.

This species is peculiar, both for the sparseness of the neuration, and for its extreme simplicity, only one of the many branches preserved being forked; it is also much more elongated than most of the species, and has an excessively long mediastinal area, reaching nearly to the tip of the wing, and, notwithstanding the slenderness of the scapular area, throwing the externomedian branches wholly upon the inner side of the apex. In the slenderness of the wing the preceding very much smaller species approaches it, and in simplicity *Gerabl. weissiana* seems nearly allied, but it is readily distinguishable from both by the extreme length of the mediastinal area.

The single specimen was obtained in the "upper division of the Thuringen carboniferous series," at Manebach, in the neighborhood of Ilmenau. Upper carboniferous.

Gerablattina weissiana. Pl. 3, fig. 1.

Blattina euglyptica var. *weissiana* Gold., Neues Jahrb. f. Mineral., 1869, 163, taf. 3, fig. 10; — Ib., Faun. saraep. foss., ii. 19.

Blattina weissiana Gold., Faun. saraep. foss., ii. 26, 51.

Fore wing. Only a part of the upper half of the wing being preserved, its form cannot be stated, but the costal margin is strongly and regularly arcuate, and the tip apparently well rounded; the veins are arcuate at the base. The mediastinal vein runs entirely parallel to and not very distant from the margin until beyond the middle of the wing, when it gradually approaches it, and terminates in the middle of the outer half of the wing; it emits nine or more straight, parallel, rather longitudinally oblique, simple branches. The scapular vein also runs parallel to the costal margin, and terminates just before the extreme tip; it begins to divide at a little distance beyond the middle of the wing, and in quick succession emits three nearly longitudinal branches, whose course cannot be traced far beyond their origin. The externomedian vein diverges slightly from the preceding in the basal half of the wing, running in a nearly longitudinal course about as far from the mediastinal vein as the latter is from the margin; it probably terminates not much further below the tip than the scapular above it,[1] and only the extreme apex is therefore occupied by this vein and its two branches; these branches are longitudinal, and arise near together, one at, the other a little beyond, the middle of the wing, and seem to crowd this part of the wing with veins more closely than elsewhere. The internomedian is represented by

[1] Wrongly represented on our plate by the outside mark, as if the internomedian vein belonged to this area.

Goldenberg as straight, and no inferior branches are preserved; a simple superior branch, running parallel to the main stem, is represented as arising at the end of the middle third of the wing.[1]

The wing is a large one, the length of the fragment being 33 mm.; its breadth, 10 mm.; the probable length of the wing, 35 mm.; its breadth, perhaps 12.5 mm.; making the breadth to the length as 1 : 2.8. Goldenberg gives the probable breadth as 15 mm., and the breadth to the length as 1 : 2.4, and this breadth is represented by the dotted lines on our plate, where Goldenberg is followed. The straightness, however, and the slight obliquity of the internomedian vein, render it probable that the internomedian area was a narrow one, more as appears in *Gerabl. balteata*, for instance, and the longitudinal direction of all the veins and all the branches render it all the more probable; for longitudinal branches in the internomedian area, are generally correlated with a narrow area; there is no reticulation in the interspaces, and the wing, if the upper surface is exposed, is of the left side.

The extreme base, the whole of the anal area, all of the internomedian area below the main vein, the neuration of the apical third of the wing, and the lower half of the margin of the entire wing are destroyed; enough, however, remains to indicate both the generic and specific alliances of the insect, and to show that it is certainly distinct from any other described form. Goldenberg's first reference of the insect as a form of *Etobl. euglyptica* was natural, from the general resemblance of the neuration to what is found in that insect; but the much greater length of the mediastinal area, not to mention the more apical division of the scapular vein, at once forbids such a reference. In the form of the wing and in the general distribution of the veins it most nearly resembles, perhaps, the American *Gerabl. balteata*, but the far more apical division of the scapular and externomedian veins, and especially of the former, separates it at once. In these points it is more closely allied to *Gerabl. Mahri*, but the wing cannot be so slender as there, nor so large, and the mediastinal area is much shorter.

Goldenberg considers this species allied to *Etobl. euglyptica* and *Bl. latinervis* on account of the uncommon breadth of the veins, and to the liassic *Legnophora Girardi* on account of the smoothness of the margin, which the veins do not quite reach.

The single specimen comes from Brücken, Canton Waldmohr, in the Rheinpflatz. Upper carboniferous.

Gerablattina balteata, nov. sp. Pl. 6, figs. 9, 10.

Blattina sp. Font.-White, Upp. carb. flora W. Va., pl. 22, fig. 16, 16[a] [ined.].

Fore wing. The form of the wing cannot be definitely stated, as a large part of both base and apex are wanting; the costal margin, however, is moderately and regularly convex, and the inner margin nearly straight, and parallel to the former, indicating a moderately slender wing of a somewhat ovate shape, tapering at either end, and largest near the middle. The veins are arcuate at the base, and probably originate near the middle of the wing. The mediastinal vein runs subparallel to the costal margin, but is straight to just beyond the middle of the wing, when it curves gradually toward the costal margin, and

[1] Two are incorrectly represented on our plate, following Goldenberg's first representation of the same.

terminates near the end of the middle third of the wing; in the fragment, which represents all but the basal fourth, there are about eight feeble, simple, gently arcuate, rather distinct, longitudinally oblique branches, and the middle breadth of the area is scarcely less than one-fourth the width of the wing. The scapular vein, in the basal third or fourth of the wing, runs in very close proximity to the mediastinal vein, then diverges from it, being directed toward the apex of the wing; but a little past the middle it returns by a broad curve to its former trend, and terminates probably just before the extreme tip of the wing; in the fragment it emits four branches, and in the apex, which is destroyed, it probably had one or two more; the first of these four is thrown off where the vein diverges from the mediastinal, viz., a little beyond the basal third of the wing; and this branch continues subparallel to the mediastinal vein, but is compound, forking once next the second forking of the scapular vein, each fork again dividing at unequal distances before reaching the border: the other branches are simple, and originate at unequal distances apart, the second in the middle of the wing. The externomedian vein follows very nearly the same sinuous course as the scapular, but constantly a little divergent from it, and widely distant from both it and the internomedian vein; it emits its first branch midway between the first two branches of the scapular vein; this forks at least once, but probably only once, at less than half way to the apex; a second branch, not shown on the plate, and obscure upon the fossil, arises opposite the fifth internomedian branch, but only its base is preserved. The internomedian vein, so far as it is clearly preserved, is straight, and considerably oblique, being parallel to the general trend of the middle portion of the externomedian vein, and, in this portion of its course, it emits five equally and widely distant, generally forked branches, which are oblique at origin, and excepting the first, very strongly arcuate beyond, becoming nearly longitudinal; directly beyond the origin of the fifth branch, or just at the end of the middle third of the wing, the vein itself becomes longitudinal, and runs scarcely convergent with the margin, probably ending in the middle of the apical third of the wing,[1] and thereafter emits one or two more simple branches.

The wing is of medium size, the fragment measuring 19 mm. in length and 10 mm. in breadth; probably the entire length of the wing was 25 mm., making the breadth to the length as 1:2.5. The upper surface of a left wing is exposed, and the more essential parts of the neuration are present, although the entire anal area, with the corresponding upper portion of the base, is gone, together with a large fragment from the apex of the wing. The most characteristic feature in the wing, one found apparently in no other palaeozoic cockroach, is the peculiar limitation of the cross neuration to broad, piceous belts, which follow the veins and their branches throughout all parts of the wing sufficiently preserved to see it, excepting the branches of the mediastinal vein; they are apparently worn from all but the basal portion of the scapular and externomedian veins, to the extent represented in the plate; but, wherever they can be seen, follow each of the veins and their branches with extreme regularity and nearly equal width, so as to cross the interspaces where these are narrow; the cross veins in these belts are very delicate, crowded, elevated, a little irregular, but usually transverse to the interspaces, and only to be seen by the aid of a magnifier; between the bands, which are about 0.75 mm. in breadth at the widest, no

[1] The outside mark on the plate (fig. 9), representing the termination of the internomedian area, should therefore be removed considerably further toward the tip of the wing.

trace of transverse markings can be seen. This peculiar structure is well brought out in fig. 16ª, of Fontaine and White's plate, but the figure of the wing, fig. 16, represents the course of the neuration as entirely wrong.

The species is, of course, based upon the wing described above, but another fragment of a wing (Pl. 6, fig. 10) has been found by Professor Fontaine; and, notwithstanding it occurs in a considerably lower deposit, and represents a part absent from the other wing (thus supplementing it, but at the same time affording no common ground for structural comparison beyond the size), we must consider it as belonging to the same species, on account: first, of its size, which agrees perfectly with the other fragment; and second, from the fact that each of the veins is accompanied by a black belt, although without the addition of the transverse veins. The fragment is that of an entire anal area, and shows that the anal furrow of this species was very deeply impressed in its basal half, more gently in its apical, was rather strongly arcuate and a little bent in the middle, but probably terminated a little beyond the middle of the basal half of the wing, being unusually short; the anal veins were simple, the first three rather distant (but the first very close to the anal furrow), scarcely raised above the surface, and bent in the same sense as the anal furrow, being subparallel to it; the other three or four are gently arcuate in an opposite sense, delicately elevated, and closely crowded. The length of the fragment is 7.5 mm.; its breadth, 3.5 mm. The black belts accompanying the veins are a little narrower than in the other fragment. The surface exposed is also that of a left upper wing.

This species is sufficiently distinguished by the banded neuration of the wings to separate it from any other. The distribution of the veins, however, shows that it falls into this genus and has certain special affinities with *Gerabl. Mahri* and *G. weissiana*; from the former of these it differs very much in the greater brevity of the mediastinal area; and from the latter it is distinguished (there are few points of comparison, from the fragmentary nature of *G. weissiana*) by the much earlier origin of the first scapular branch. It has closer affinities, in most of the broad features of its neuration, with the other American species of the genus, *G. fasciata*, but to the fine subdivision of the veins of the latter it has nothing to correspond; neither has it in the length and multiple division of its scapular vein, nor in the basal union of the principal veins, nor in the structure of the anal area.

The first and principal fragment described above was found by Messrs. Fontaine and White at Cassville, Monongolia County, W. Va., in the roof shales of the Waynesburg coal, or the very highest of the beds of the upper productive coal series, in the nomenclature of the first Pennsylvania survey, or the beds termed Permo-carboniferous by Professor Fontaine. The other fragment comes from Bellaire, Ohio, near Wheeling, W. Va., associated with plants of the upper productive coal beds, in shales twenty feet below the Pittsburgh bed of coal, which lies at the base of the upper productive coal series, and clearly within the carboniferous series proper. Professor Fontaine, who kindly sent me the specimens, writes me that the two localities are eighty miles apart, and separated by three hundred feet of strata. Upper carboniferous; Permo-carboniferous.

Gerablattina fascigera. Pl. 6, figs. 1, 2.

Blattina fascigera Scudd., Proc. Bost. soc. nat. hist., XIX, 238–39; — Ib., Entom. notes, VI, 35–36.

Fore wing. The wing is broad and nearly equal, the humeral lobe full, the costal margin very gently and very regularly convex, the inner margin nearly straight until the apical third of the wing, where it is roundly bent and thus narrows the well-rounded apex; the veins originate below the middle of the wing, and all but the mediastinal and the anal veins from a single root considerably below the middle, from whence they curve rather strongly upward. The mediastinal vein is very faintly preserved, and runs subparallel to the costal border, with a similar arcuation, to the middle of the apical half of the wing, and then curves toward it and meets it at the extremity of the fragment, or beyond the middle of the apical fourth of the wing;[1] it emits a very great number of closely crowded branches, which are only visible in the apical half of the area, nowhere visible throughout their length, both their bases and even the principal vein itself being obliterated, and the course of the vein only indicated by the position of their outer extremities; enough remains to show that they are generally simple (in a single instance a fork is seen), straight or faintly arcuate, the convexity away from the costal margin and oblique, the apical ones becoming slightly longitudinal; in the middle of the wing the area occupies somewhat less than one-fourth the breadth of the wing. The common stem from which arise the scapular, externomedian, and internomedian veins and the anal furrow, runs in a straight line parallel to the nearly obliterated mediastinal vein until just past the middle line of the wing, at about the middle of the basal third of the wing, when they all divide simultaneously, excepting the two lower, which do not separate at once from each other. Beyond this common point of departure, the scapular vein is at first gently arcuate, shortly afterwards, after its first branch, nearly straight, running throughout parallel to the costal margin, but at a wide distance from the mediastinal vein, and terminates at the tip of the wing; it is, however, slightly arcuate, in an opposite sense to its first arcuation, between each pair of branches, the main stem and each branch appearing, almost equally, as forks of the preceding part of the main stem; these branches are four in number; the first differs from the rest; it parts from the main stem a little beyond the basal third of the wing, soon becomes nearly longitudinal, but gradually approaches the mediastinal vein, and finally forks, the two branches of the fork closely resembling branches of the mediastinal vein; the second branch of the scapular vein arises a little beyond the middle of the wing, the fourth midway between this and the apex, and the third midway between the two; the second is doubly, the third simply forked, and the fourth simple; the apical shoots of these branches strike the margin of the scapular area at increasingly wider intervals, the lower interspaces being similar in width to those of the inner margin. The externomedian vein, beyond the point of common origin,[2] runs in a nearly straight but faintly wavy course nearly along the middle of the wing, parallel to the preceding, and has similar arborescent but inferior branches, also emitted at irregular intervals; the first, which is doubly forked, is emitted at the centre of the wing; the second and third, which are sim-

[1] The mark separating the mediastinal and scapular areas is placed a little too far toward the apex in the plate.

[2] Represented on the plate a little incorrectly, as it should be united at its base with the scapular vein.

ple, are thrown off, one opposite the first fork of the first branch, the other opposite the last branch of the scapular vein; there is also the commencement of an oblique, stout cross-vein opposite the basal branch of the scapular vein, running half way to the second branch of the internomedian vein, almost precisely similar to what occurs in *Etobl. venusta* and in *Arch. acadicum*, both, like this, American species, and members of the same subfamily. The internomedian vein and anal furrow part from each other almost immediately after their common departure from the united vein, and the internomedian then runs in an irregularly straight line, subparallel to the externomedian vein, and terminates a little further from the tip than the mediastinal vein; it curves downward a very little at the origin of its third branch, so as to be a little more distant from the externomedian between its third and fourth branches than before; it has in all five branches, which originate at subequidistant intervals, the last of which is simple, the others more or less deeply and simply forked; they are all more or less arcuate and somewhat longitudinally oblique. The anal furrow, from the common origin of all the veins, is straight, very deeply impressed on the basal half, somewhat longitudinally oblique, and terminates in the middle of the inner margin:[1] the anal veins are very independent of the anal furrow, consisting first of a pair of compound veins arising from the extreme base of the wing at the origin of the common stem of the principal veins, and running in an obliquely longitudinal course to strike the apical half of the margin of the anal area, and leaving a wide interval at the base between them and the common stem and the anal furrow; and in the angle four closely approximated, straight, similarly oblique, simple veins.

The wing is a large one, measuring 35 mm. long as far as preserved, and 15.5 mm. broad: the entire length of the wing must have been 38 mm., and the proportion of the breadth to the length as 1 : 2.5. The wing is perfect, except a slight fragment of the tip and a little piece of the base of the anal area. The specimen shows the upper surface of a left wing. The surface is covered with a very delicate network of raised veins, which are arranged more or less irregularly, transverse to the interspaces, in a broad marginal band around the apex and inner border of the wing, and as an entirely irregular polygonal reticulation upon the disc; no network can be seen, probably from poor preservation, upon the mediastinal area.

This species was wrongly compared by me to *Etobl. primaeva*, with which it has very few special points in common, and from which it is widely distinct in the structure of the mediastinal and anal veins. It seems to belong certainly in the genus Gerablattina, but forms perhaps a distinct section, differing from all others in the extreme multiplicity of the mediastinal branches, in the basal coalescence of the other principal veins, in the arborescent division of the scapular and externomedian veins, and in the longitudinality and dichotomy of the anal veins, and their wide separation from the anal furrow. In the broad features of its neuration, however, and particularly in points of division of the scapular, externomedian, and internomedian areas, it resembles most and to a considerable degree the only other American species of the genus, *G. balteata*, but it differs from it in all the points above mentioned, and in lacking the banded ornamentation of the veins.

The single specimen found was obtained by Mr. R. D. Lacoe, at Pittston, Penn., and lies on a piece of black carbonaceous shale coming from the interconglomerate beds of the true

[1] The termination of the anal area is marked in the plate on the wrong side of the anal vein.

coal measures at the anticlinal next north of that in which the Pittston species of Lithomylacris occur, and also on the south-east side. Lower carboniferous.

Hermatoblattina nov. gen. (ἕρμα, Blattina).

Blattina Auct. (pars).

The two species which form this genus differ in the nature of the mediastinal area in the front wings; in one it is nearly one-third the breadth of the wing, equal nearly to the extremity, and terminates close to the tip of the wing; in the other it is fully a third the breadth of the wing near the base, and diminishes regularly to the extremity, which is somewhat beyond the middle of the outer half of the wing; in both the vein is gently sinuous and the branches frequent, oblique and generally simple. The scapular vein, although beginning to branch before the middle of the wing, has only two or three branches, which are inferior, diverge but slightly, and may or may not fork, so that the area occupied by the vein is slight, and terminates at the tip of the wing. In consequence of the inferior position of the branches, the equal interspace between the mediastinal and scapular veins is marked by oppositely diverging branches. The externomedian vein is very similar to the scapular in extent, place and mode of branching, but the branches may be either superior or inferior, but always fall upon the margin below the apex of the wing. The anal and internomedian areas are very broad at base, occupying more than half the breadth of the wing, but narrow rapidly, the internomedian being considerably arcuate, and terminating not very far from the apex; the branches of the externomedian are as oblique as those of the mediastinal area, and although very long and straight, fork very little. The anal furrow is not very pronounced, more or less arcuate, and terminates not far beyond the basal third of the wing; the anal veins are subarcuate, subparallel, frequent and simple. Nothing is known of the genus but front wings, which are unusually stout, the breadth being contained in the length scarcely more than two and a quarter times; with the possible exception of Petrablattina, the average form is stouter than in any other genus, although other genera contain stouter species.

This genus is peculiar for the inferior position of the branches of the scapular vein, a characteristic it shares only with Oryctoblattina, from which it is readily separated by the slender development of the same vein, and by the different nature of almost all of the others. But for the inferior position of these branches of the scapular vein, it could hardly be separated from Gerablattina. From Archimylacris and Etoblattina it is distinguished by the breadth and extent of the mediastinal area. From Anthracoblattina it is again separated by the inferior position of the scapular branches. The limited extent of the combined areas of the scapular and externomedian veins readily distinguish it from Progonoblattina, while the totally different nature of the externomedian vein in Petrablattina permits of no confusion with that.

The two species belonging here come from the old world, and are of large size.

Hermatoblattina wemmetsweileriensis. Pl. 4, fig. 11.

Blattina wemmetsweileriensis Gold., Faun. saraep. foss., ii, 19, 24, 51, taf. 1, fig. 9.

Fore wing. The wing is broad and nearly equal, almost imperceptibly diminishing in size up to the apical fourth of the wing;[1] the costal margin is very gently and regularly

[1] This scarcely appears on our plate, where the apical half of the costal margin is a trifle too full.

convex, the inner margin straight, and the apex well rounded, no doubt, but broken in the specimen. The veins probably originate a little above the middle of the wing, and are gently arcuate at their base. The mediastinal vein runs parallel to the costal margin, but beyond the middle of the wing scarcely recedes from it, afterwards curving very slightly upward, and striking the apical border not a great way above the tip of the wing; it emits a large number, thirteen or more, of rather frequent branches, most of which are simple (the penultimate doubly forked), parallel, the earlier ones oblique, the later longitudinally oblique; the area is a little more than a fourth the width of the wing in the middle. The scapular vein runs closely parallel to the mediastinal throughout its course and emits, at equal distances apart, three inferior, apically forked branches, the first scarcely beyond the basal third of the wing, the third somewhat before the end of the middle third of the wing, and all with their forks crowded closely together into the space between the tip of the mediastinal vein and the extreme apex of the wing. The externomedian vein, on the other hand, runs close and parallel to the internomedian vein; but it also has three branches, which are slightly further apart thanin the preceding, but originate almost exactly opposite them, the last simple, the others compound, filling the area with veins as closely crowded as in the preceding area; the branches being superior while those of the scapular area are inferior, brings the branches opposed to each other in a sense the reverse of what is commonly found in palaeozoic cockroaches, and gives the wing a peculiar appearance. The internomedian vein is gently and decreasingly arcuate from the base outward, and is very regular, but, at the origin of its last branch, takes a direction a little above its former course, the branch and the apex of the vein making common forks of the preceding part of the stem; it terminates before the apical sixth of the wing, and emits eight equidistant, simple or forked, straight veins, all but the last of which are oblique; the vein originating above the middle of a broad wing, and extending so far toward the tip, gives this area a great extent, making it not a little remarkable that some of its basal branches, all of which are more distant than the mediastinal branches, should be simple, and so very straight. The anal furrow is apparently deeply impressed at base, pretty regularly and very strongly arcuate, terminating a little beyond the basal third of the wing; the anal veins, nine in number, are, so far as preserved, simple, straight, and closely crowded toward the inner angle, gently arcuate and more distant next the anal furrow.

The wing is a large one, the fragment measuring 34 mm. in length and 16 mm. in breadth; the length of the wing can vary little from 37 mm., making the breadth to the length as 1 : 2.3. It is almost completely preserved, a little of the extreme base and tip only wanting. If the upper surface is exposed, the wing is from the right side; the reticulation is mostly effaced, but with a lens one may see exceedingly delicate transverse wrinkles, giving the wing a shagreened appearance.

Goldenberg compares this species with *Etobl. primaeva*, with which, however, at least above the internomedian area, it has very little in common, and from which it differs greatly in shape; the other species of the genus agrees far better with *Etobl. primaeva*. This species differs from *Herm. lebachensis* in the structure of the mediastinal area, which is here almost equal, and in the distribution of the externomedian branches, which are superior and not inferior.

The single specimen was found in a bluish bituminous shale in the neighborhood of Wemmet-weiler, near Saarbrücken, Germany. Upper carboniferous.

Hermatoblattina lebachensis. Pl. 1, fig. 11.

Blattina lebachensis Gold., Sitzungsb. math.-nat. Cl. k. Akad. Wiss. Wien., IX, 38 (undescribed).

Blattina lebachensis Gold., Palaeontogr., IV, 22, 23, taf. 6, fig. 7; — Ib., Foss. Ins. Saarbr. 6, 7, taf. 4, fig. 7; — Ib., Faun. saraep. foss., ii, 20, 27, 51, taf. 1, fig. 20; — Gieb., Ins. Vorw., 316; — Gein., Geol. Steink. Deutschl., 150.

Fore wing. The extreme base and a considerable part of the apex of the wing being lost, its form cannot be given in detail; but it is remarkable for its great breadth near the base, due to the unusual convexity of the basal half of the costal margin, which is a little exaggerated in the plate; beyond this fulness the costal margin is straight, and gradually approaches the inner margin, which is itself very gently and regularly convex, so that the wing tapers considerably beyond the basal third. The veins appear to originate not far from the middle of the base, perhaps a little above it, and have a long basal arcuation. The mediastinal vein is very broadly and gently sinuous, straighter than the costal margin, so that the mediastinal area, which terminates just at the tip of the fragment, and probably not much before the apical sixth of the wing, narrows toward either extremity from the middle of its basal half, being at its broadest about one-third the width of the wing: it emits eight distant, straight branches, all excepting one which is forked, simple, the basal one transversely, the apical ones a little longitudinally oblique. The scapular is throughout close and parallel to the mediastinal vein; it seems to be coalesced with the externomedian vein in the basal fourth or third of the wing, and to have three inferior, simple, longitudinal, arcuate, apically distant branches, the first arising beyond the basal third of the wing and reaching the extreme tip, the last arising at about the end of the middle third of the wing. The externomedian vein is very broadly and gently sinuous, running down the middle line of the wing, terminating just below the tip, and emitting three inferior, simple, gently arcuate, sublongitudinal, apically distant branches, arising almost opposite those of the scapular vein. The internomedian vein is strongly and regularly arcuate, apically straight or slightly arcuate in a reversed sense, terminating about opposite the end of the mediastinal vein, and emitting half a dozen rather closely approximate, very long, oblique, straight or sinuate simple branches, the penultimate, in the individual figured by Goldenberg in his Fauna saraepontana, ending in the preceding branch.[1] The anal furrow is lightly impressed, gently convex, and terminates a little before the middle of the wing; the anal veins, five or six in number, are simple, not very closely crowded, and similarly arcuate.

The wing is a large one, the fragment measuring 28.5 mm. in length, and 16 mm. in breadth; the length of the wing may be anywhere from 32 to 36 mm., so that the breadth is to the length as 1 : 2 – 2.25. The wing is from the left side, and the upper surface is exposed; the recticulation of the wing is composed of polygonal, mostly tetragonal or pentagonal, cells, forming a network which may be seen with the naked eye, and are more delicate on the disc than near the apex.

[1] In his first description, Goldenberg describes the six internomedian branches as all simple excepting the fourth, which is forked; and he figures them as all simple and running to the margin excepting the third, which is forked. In his second description, based apparently on the same specimen, he describes them as all simple and figures them as we have here described.

Goldenberg compares the species to *Etobl. euglyptica*, from which he says it differs in its larger size, broader mediastinal area, larger number of branches in the anal area, and a wider interspace between the scapular and internomedian areas. The differences between the two species in every part of the wing are so great that it is difficult to see any special point they have in common, excepting the simplicity of the internomedian and anal branches, which is common to a great number of forms. Goldenberg subsequently compares this species to *Etobl. anaglyptica*, with which it agrees better both in shape and in neuration, but it is still larger than that species, and differs besides in the brevity and non-production of the internomedian area. It much more closely resembles *Etobl. primaeva* than either, although still widely distinct from it. From the only other species of the genus it is distinguishable by the brevity and unequal breadth of the mediastinal area, the inferior origin of the externomedian branches, and the tapering form of the wing.

Several specimens must have been found in the iron-stone nodules of Lebach above Saarlouis, Germany, as Goldenberg remarks that it appears there to be common. Dyas.

We come now to the more aberrant forms of this group of carboniferous cockroaches, the preceding genera being more closely allied to each other than to either of the groups which are to follow, and which comprise between them but five species.

Progonoblattina nov. gen. (πρόγονος, Blattina).

Blattina Auct. (pars).

In the genus now under consideration the mediastinal vein of the front wing runs parallel and near to the costal border, occupying, even in the slender species, less than a third of the breadth of the wing, and terminating only a little beyond the middle of the costal margin; its branches are frequent, oblique, gently arcuate, and simple. The scapular vein is of much greater importance, commencing to branch far toward the base of the wing, emitting five or six forking branches, and terminating only just before the tip of the wing; the branches are superior, but longitudinal or scarcely oblique, and at the termination of the mediastinal vein the are aoccupies about half the breadth of the wing. The externomedian vein early divides into several principal branches, which are very similar in nature to those of the preceding vein, and occupy on the margin a similar extent; according, however, to the curve of the main scapular vein, this area may occupy, with its many doubly forking longitudinal branches, more or less room than the scapular area; together they occupy the entire apical half of the wing, and more than a third of the basal half. The internomedian vein, which originates in the middle of the base of the wing, slopes in a more or less arcuate curve toward the middle of the inner margin; it emits only three or four branches, simple or apically forked, and altogether plays a very insignificant part in the wing, the anal furrow, which is slight and considerably more arcuate than the internomedian vein, terminating beyond the middle of the basal half of the wing. The anal veins are more oblique than the anal furrow, not very numerous, subparallel, and simple or forked.

Nothing but upper wings are known, and these vary exceedingly in slenderness, one of the two species being the slenderest known species, while the other is a little below the general average.

This genus is readily separated from all the preceding by the much greater common expanse of the scapular and externomedian veins, and the unimportance of the internomedian area; indeed, in these particulars it surpasses any of the ancient genera of cockroaches. From Oryctoblattina it is readily separated by the brevity of the mediastinal area, and by the approximation of all the veins in the basal half of the wing. The totally different character of the externomedian vein distinguishes it from Petrablattina, although it approaches that genus in the abundance of the neuration.

The two species, which differ widely from each other, are European; one of them is a large species, the other rather small.

Progonoblattina helvetica. Pl. 3, fig. 10.

Blattina helvetica Heer. Viertelj. naturf. Gesellsch. Zürich, IX. 287, 291–93, pl., fig. 1; — Ib., Urw. Schweiz., 592, note; — Ib., Monde prim. suisse, 22, fig. 16 c[b]; — Gold., Faun. saraep. foss., ii, 19.

Blatta helvetica Heer. Prim. world Switz., I. 20, fig. 16 c[b].

Fore wing. The wing is pretty regularly elongate-obovate, the costal and inner margins about equally and considerably convex, the apex tapering but well rounded. The base of the wing is broken, especially next the margins, so that the mediastinal vein can be traced only a short distance; here it runs near and parallel to the margin, and by a gentle curve strikes it at the end of the middle fifth of the wing; the width of the area is less than a sixth that of the wing, and in the portion preserved only a couple of branches are seen, widely separated at their origin, simple and arcuate, but brought near together by their unusual longitudinality, so that it is doubtful if there are more than five or six branches to the vein. The following areas, as Heer has pointed out, are difficult to separate, from the fact that the base of the wing is lost, and they all divide so early as to exhibit at the edge of the fragment, very near the base, no less than eight nervules between the mediastinal vein and the anal furrow. It would, however, present a structure so abnormal were any but the nervure next the anal furrow to belong to the internomedian vein, that it seems almost certain that we must divide seven of them between the scapular and externomedian veins; the three lower of these have an oblique course at the base, and are separated by an unusual width from the upper four, which in their turn have a longitudinal course; and these two bundles of nervules we may consider as belonging to the externomedian and scapular veins respectively. On this assumption the scapular vein is longitudinal and nearly straight, and terminates just above the extreme tip of the wing; it has six longitudinal branches, three of which originate within the basal quarter, two near the middle and one next the tip of the wing; the first and last are simple, the others simply, the middle one doubly forked; the basal branches curve very gently upward toward their tip, but the others are wholly horizontal. The externomedian vein is more difficult to define; the three veins with which it starts from the base of the fragment are very similar in character, and being perfectly parallel next the edge (which must lie within the basal fifth or sixth of the wing) it is not clear which should be looked upon as the main stem; but the main stem may be said to break close to the base into three branches which run close together toward the middle of the outer half of the inner edge of the wing; omitting the upper branch of the upper vein, each of these three stems forks at or just beyond the end of the basal third of the wing, and each of these forks again divides at irregular distances from this point, but most of them not far from the end of the middle third of the wing; the upper stem, however, has an upper branch, which starts in the middle of the wing and is doubly forked, running in a very straight, longitudinal course almost exactly through the middle line of the wing, its first fork near the end of the middle third, the second near the tip of the wing. The internomedian vein is scarcely arcuate, and by an apical fork is thrown a little further out than it otherwise would be, reaching close to the end of the middle third of the wing; besides the apical fork it has three branches, emitted near together, not far from the end of the basal third of the wing, straight, oblique and apically forked. The anal furrow is not impressed, regularly and considerably arcuate, bears an inferior, nearly straight branch near the middle of its preserved course, and terminates considerably beyond the basal third of the wing; the anal veins are scarcely so crowded as the others, simple, forked or compound, arcuate, and subparallel to the anal furrow.

The wing is a very large one, the fragment measuring 39 mm. in length, and 17 mm. in breadth. The probable length of the wing is 42 mm., making the ratio of the breadth to the length as 1 : 2.5. The wing is from the left side and shows the upper surface, which is covered with a network of very numerous, closely crowded, delicate cross veins, visible only by aid of a glass. Heer compares the species with *Etobl. primaeva* and *Etobl. didyma*, but fails to point out its closer alliance to *Progon. Fritschii*, which he describes immediately afterwards, or to notice the feature which is most characteristic of it, viz., the exceedingly early division of the scapular and externomedian branches, and the nearly uniform longitudinal course of all these branches; no other palaeozoic cockroach has such an abundance of longitudinal veins filling the larger part of the wing. From its congener it is readily distinguished by this feature, and also by the smaller extent of the scapular area as compared to the externomedian, and the far greater size and stoutness of the wing.

A single specimen, found in the anthracitic schists of the lower quarry of Erbignon, Canton Wallis, Switzerland, is remarkable as the only animal yet discovered there. Middle or upper carboniferous.

Progonoblattina Fritschii. Pl. 3, fig. 12.

Blattina Fritschii Heer, Viertelj. naturf. Gesellsch. Zürich, IX, 287, 293–94, pl., fig. 2;—Gold., Faun. saraep. foss., ii, 19.

Fore wing. The wing is exceptionally slender and equal, both borders being almost perfectly straight; the apex and outer half of the inner margin are lost, but the part preserved is more than three times as long as broad. The veins originate just above the middle of the base of the wings, and have the slightest possible upward curve in passing outward. The mediastinal vein runs subparallel to the costal margin, but always almost imperceptibly approaching it, more rapidly toward the tip, which strikes the margin at the end of the fragment, or a little beyond the middle of the wing; in the middle the area is a little less than one-third the width of the wing, and it is occupied by about seven longitudinally oblique, slightly arcuate, simple veins. The scapular vein runs close beside the mediastinal through the basal quarter of the wing, then turns abruptly although only slightly from it, and runs in a broad, arcuate curve past the middle line of the wing, to strike the border just above the tip, or where a continuation of its basal course would have brought it; it has five superior, obliquely longitudinal branches, the first emitted at the point where it diverges from its first course, which is doubly forked; the next, which is forked, at the end of the basal third of the wing; and three simple, more closely approximated veins, at and a little beyond the middle of the wing. The externomedian has an arcuate course, closely parallel to the scapular vein, through the basal third or thereabouts; here it is broken up into three principal stems, the upper of which runs in a slightly arcuate course to a point as far below the extreme apex as the scapular vein is above it, emitting in the apical third of the wing three simple, nearly longitudinal branches, which occupy the apex of the wing; the middle stem runs close to the preceding, and emits, at one-third and two-thirds way to the border, two superior, simple, straight, and nearly longitudinal branches; the lower is basally forked, the forks resembling the basal branch of the middle stem. The internomedian vein is rather gently and regularly arcuate, terminating next the middle of the lower border; it has three simple branches, and one (the first) forked branch, approximate, straight, and oblique. The anal furrow is a little more strongly, but just as regularly arcuate, and strikes the margin at the end of the basal third of the wing; the anal veins, four in number, are simple, distant, slightly divergent, and similarly arcuate.

The wing is of medium size, but appears rather small from its narrowness, the fragment measuring 22 mm. in length and 6.5 mm. in breadth;[1] the wing must have measured 23.5 mm. in length, so that the breadth was to the length as 1 : 3.6. If the upper surface is preserved, it is from the left side. It is very nearly perfect, only a portion of the tip and lower apical margin being lost. The reticulation between the veins is mostly destroyed, but with a glass one may see, particularly in the anal area, excessively delicate wrinkles or little streaks, giving a shagreened appearance to the wing, and indicating the presence of closely crowded cross neuration.

Heer remarks that this species comes next to *Gerabl. Münsteri*, but it differs more from that than from many other species, such as *Etobl. flabellata* and *Etobl. affinis*; but even from these it is widely different in the distribution of the scapular and externomedian branches. From its single congener, *Progon. helvetica*, it is readily distinguished by its exceedingly different size and shape, and differs also in its broader mediastinal field, the less basal division of the scapular and externomedian veins, and the more oblique course of the scapular branches. Indeed, it differs so much from it, that were it not for its essential agreement in the points in which they both differ from the other palaeozoic cockroaches, it would seem more rational to separate them generically: which a more extended acquaintance with palaeozoic Blattinarians may yet compel us to do.

One specimen, from the coal-measures of Manebach, near Ilmenau, in Thüringen. Upper carboniferous.

Oryctoblattina nov. gen. (ὀρυκτός, Blattina).

Blattina Auct. (pars).

The mediastinal vein of the front wings runs parallel and very close to the costal margin, closer than in any other of the genera here described, and terminates only a little before the middle of the outer half of the wing: it emits numerous branches almost transverse to the wing in the basal portion, but notwithstanding their brevity often forked in this part of the area. The scapular vein is very peculiar; it begins to branch a little beyond the

[1] Heer says 7.5 mm., but his figure represents it as if it were 6.5 mm., and this is more likely to be correct.

middle of the basal half of the wing, and the main stem terminates on the costal margin a little beyond the middle of the apical half of the wing, keeping widely distant from the mediastinal vein throughout its course; it emits numerous parallel, straight, longitudinal and forking branches, most of which, in the only species known, originate from a vein parallel to the main stem, which is emitted abruptly from near the base of the second branch; the first branch terminates at the extremity of the inner margin, so that the entire apex of the wing belongs to the scapular area, which is the largest in the wing. The externomedian vein branches near the middle of the wing, and before that is equally separated from the neighboring veins by a wide space; it has only two or three branches which are superior, and perhaps simple, and they occupy a very restricted area, only the apical fourth of the inner margin being covered by their extremities. The internomedian vein is again very peculiar, this being the only genus known in which a wide space intervenes between the anal furrow and the branches of this vein; it assumes to a considerable degree the form of the externomedian vein, first branching beyond its middle, and then emitting a very few simple or forking, but inferior branches. The anal furrow is conspicuous, very arcuate, originating in the middle of the base of the wing, and terminating in the middle of the basal half of the inner margin; it is rendered more conspicuous by the fulness of the anal area, which breaks the regular continuity of the margin at the extremity of the anal furrow, a peculiarity occurring in no other carboniferous cockroach; the anal veins are very few, sinuous, subparallel, simple and oblique. The wing is of the average slenderness, the breadth being contained in the length about two and six-tenths times. Nothing is known of other parts of the body.

This most exquisite of the carboniferous cockroaches is very widely separated from the rest. The peculiarities of nearly every part of the wing separate it at once from nearly every other genus; the extreme narrowness of the mediastinal area, the wide separation of the main veins from one another (accounted for perhaps by the excessive development of reticulation), the independence of the internomedian vein, and the fulness of the inner margin in the anal area, occur nowhere else; the inferior origin of the branches of the scapular vein are found elsewhere only in Hermatoblattina, and the wide extent of the area occupied by the combined scapular and externomedian branches are reproduced only in the aberrant genera among which it is placed. From Progonoblattina it is separated by the small space, and that wholly on the inner margin, which is allotted to the externomedian veins, besides the points first mentioned; and from Petroblattina, its other nearest ally, it is conspicuously distinct both by the nature of the externomedian vein, and by the wide separation of the main veins in the basal half of the wing.

The genus is only known from Europe, and is the only one represented by a single species, which is of rather small size. More than twenty years ago Giebel suggested that this species should form the type of a distinct genus.

Oryctoblattina reticulata. Pl. 4, fig. 13.

Blattina reticulata Germ., Verst. Steink. Wettin, vii, 87–88; viii, taf. 39, fig. 15ᵃ, 15ᵇ; — Gieb., Deutschl. Petref., 637; — Ib., Ins. Vorw., 316; — Gold., Faun. saraep. foss, ii, 19.

Fore wing. The wing is of a very graceful form, oblong obovate, the costal margin tolerably convex next the base, with a very slight humeral lobe, beyond very gently and regularly convex; the inner margin is straight, excepting for the fulness of the anal area, but a large fragment of the apex of the wing is wholly lost. The veins originate from a little above the middle of the base, and have a gentle basal arcuation. The mediastinal vein runs in close proximity and subparallel to the costal margin, constantly but very gradually approaching it, emitting numerous oblique branches; in the basal half of the area the branches are forked half way to the margin, and between the forks are other parallel, spurious branches; but beyond the middle of the wing spurious and forked branches become alike very closely crowded, oblique, simple branches, which continue along the edge, between the apparent termination of the main vein (about the end of the middle fifth of the wing) and the scapular vein; in the middle of the wing the area is only about one-tenth the width of the wing. The course of the scapular vein has been described sufficiently under the generic description; it will be sufficient to add here that there are about half a dozen longitudinal shoots to the offshoot of the second scapular branch, and that these become more and more closely crowded toward the costal margin; and that the two principal branches of the scapular vein originate close together, the second forked at some distance beyond the offshoot. The externomedian vein is gently arcuate in its basal half. The internomedian vein closely resembles it, and in this particular this species is widely separated from all others; but it is a little more arcuate, has inferior instead of superior branches, and terminates about the middle of the apical half of the inner margin. The anal furrow is distinct and arcuate, bending downward to the margin more rapidly than usual; the anal veins are only three in number, crowded close together in the middle of the area, traversing it obliquely, with a slightly sinuous, obliquely longitudinal course.

The wing is one of the smaller of the medium-sized ones, the fragment measuring 19 mm. in extreme length and 8.5 mm. in breadth; it represents a wing of the same median breadth and a length of about 22 mm.; so that the breadth to the length must have been as 1 : 2.6. The wing is from the left side. It is marked by a distinct and exceedingly delicate and perfect reticulation of mostly pentagonal cells, two or more rows being seen between the wider interspaces; but in the narrower ones, as between the closely approximated scapular branches, these are reduced to a single series of tetragonal cells, formed by single, transverse raised lines, as far apart as the interspaces, but still no smaller than the pentagonal cells; next the border, between the extremities of the mediastinal and scapular veins, these cells form, by the absence of their cross bars, spurious veinlets as long as the apical width of the mediastinal area; between the anal furrow and the nearest internomedian branch they do the same, but the veinlets are longer; and in the apical half of the anal area the same thing occurs on a smaller scale.

This wing is so peculiar that it can be compared with no other. Germar and Giebel both describe the scapular vein as the mediastinal, and the mediastinal as a delicate, longitudinal vein running down the middle of the mediastinal area.

The single specimen described by Germar was found at Wettin, Germany. Upper carboniferous.

Petrablattina nov. gen. (πέτρα, Blattina.)

Blattina Auct. (pars).

The mediastinal vein runs parallel to and not very distant from the costal margin (the area occupying perhaps one-fourth of the breadth of the wing), and terminates at some distance beyond the middle of the costal border; it is abundantly supplied with straight, oblique, simple or forked cross-veins. The scapular vein, contiguous to, perhaps united with, the externomedian in the basal part of the wing, is of small importance, emitting in the apical half of the wing only two or three branches, which are superior, simple, or furcate, and terminate on the costal margin, the whole tip (in one species at least, and perhaps in both) belonging to the externomedian vein. The externomedian vein is the most peculiar in the wing; as soon as it is free from the common basal union of all the veins, it curves strongly backward to about the middle of the inner margin, in close proximity to the internomedian vein; and from its superior, now outer, surface emits a large number of parallel, forking veins, which terminate on the apex and outer half of the inner margin of the wing. The combined internomedian and anal areas are very broad at base, occupying fully two-thirds the breadth of the wing, and retain their breadth for some distance and then narrow with excessive rapidity, dividing about equally between them the common space; the branches of the internomedian vein are five or six in number, straight or arcuate, simple or occasionally forked. The anal furrow is very arcuate, not very prominent, and terminates near the middle of the basal half of the wing; the anal veins are frequent, arcuate, but not so strongly as the furrow, and simple or occasionally forked. Only upper wings are known.

The wings are stouter than usual, although they are not sufficiently well preserved to give any more definite statement than that they are, on the average, stouter than any other, excepting probably Hermatoblattina, and possibly Anthracoblattina.

This genus is remarkable for the close union of the veins at the base, and for the very strong curvature of the externomedian vein, by which it resembles somewhat the anal furrow, and for the contrasted longitudinality of the branches which spring from it. In these particulars it differs strikingly from every other genus, and can be confounded with none of them.

Only two species have been described, one of which is European, and the other, known only by a very small fragment of a wing, American; they are both of rather small size.

Petrablattina gracilis. Pl. 4, fig. 4.

Blattina gracilis Gold., Palaeontogr., IV, 23, taf. 3, figs. 3, 3[a]; — Ib., Foss. Ins. Saarbr., 7, taf. 1, figs. 3, 3[a]; — Ib., Faun. saraep. foss., ii, 20, 27–28, 51, taf. 2, fig. 1[a]; — Heer, Viertelj. naturf. Gesellsch. Zürich, IX, 288; — Gein., Geol. Steink. Deutschl., 150.
Blatta gracilis Gieb., Ins. Vorw., 321.

Fore wing. The wing is of a regular elliptical form, broadest in the middle, tapering more rapidly toward the apex than toward the base, both costal and inner margin equally and rather gently convex, the tip a little pointed, but well rounded. The veins all originate above the middle of the upper half of the base, but, excepting the anal furrow, have no basal curve. The mediastinal vein runs subparallel to the costal margin, but in a straight line, nearly to the middle of the wing, and then curves very gradually to the border, which it reaches a little before the end of the middle third of the wing; the area is a little less than a fourth the width of the wing; its basal half is filled with closely crowded, arcuate, oblique, simple branches, the apical half with similarly crowded and arcuate, longitudinally oblique, much longer, and usually forked branches. The scapular, externomedian, and internomedian veins evidently spring from a single stem, according to Goldenberg; the internomedian first separates itself from the others, but the other two appear to be united almost throughout the basal third of the wing; the scapular vein then turns obliquely downward in parting from the mediastinal vein at the end of the basal fourth of the wing, in a direction toward the middle of the outer half of the wing; but it very soon parts widely from the externomedian vein, and runs in a longitudinal, broadly arcuate course to the costal margin, just before the apical eighth of the wing; it emits three long, longitudinal, but obliquely arcuate branches, simple or deeply forked, the first before the separation of the vein from the externomedian. The externomedian vein continues the direction of the united scapular and externomedian veins, following closely the internomedian, and terminating on the inner border, about the end of the middle fifth of the wing; it emits at a wide angle about ten closely crowded, longitudinal veins, many of which fork singly or doubly, nearly all of them broadly arcuate, the upper curving slightly upward, the lower downward, and together embracing a very extensive area, including the entire apex of the wing. The internomedian vein has a bent, arcuate course, and emits about seven long and simple, sinuous, closely crowded branches, the marginal extent of this area being rather less than that of the anal area. The anal furrow is distinctly impressed, pretty regularly and very strongly arcuate, striking the margin at about the end of the basal third of the wing; the anal veins, nine in number, are closely crowded, arcuate, and simple.[1]

The wing is below the medium size, measuring 18.5 mm. in length and 7.5 mm. in breadth; a little of the base, however, is destroyed, which would add about 1.5 mm. to the length, making it 20 mm. long,[2] and the breadth to the length as 1 : 2.6. The wing is from the right side, the upper surface exposed, with a swollen anal area; from the condition of its preservation, it cannot be determined whether there is any interspacial reticulation.

Goldenberg compares this species to *Etobl. anaglyptica* and to "*Blattina formosa* Heer" from the Lias, but I fail to see the slightest ground for any special comparison; certainly not with the latter; while the peculiar basal connection of the principal veins, and, above all, the distribution of the externomedian branches, forbid comparison with any palaeozoic form, excepting the following species, from which it differs greatly in the multiplicity of its branches and in its slenderer form. Indeed, in the crowded condition of its venation it alone of all the palaeozoic cockroaches, excepting *Etobl. insignis*, shows any tendency toward a thickening of the membrane of the wing, which often appears, in ancient types, to have commenced by the multiplication of nervules.

The single specimen known comes from an ironstone nodule from Lebach, above Saarlouis, Germany. Dyas.

Petrablattina sepulta. Pl. 6, fig. 7.

Blattina sepulta Scudd., Proc. Amer. assoc. adv. sc., XXIV, B, 111, fig. 2; — Ib., Can. nat. [n. s.] VIII, 89–90, fig. 1; — Ib., Ins. carb. Cape Breton [p. 2] fig. 1.

Fore wing. The wing is so fragmentary that it is impossible to say anything more of the form than that the middle of the costal and inner margins are gently convex, the former nearly straight. The veins would appear to have originated considerably above the middle of the base. The mediastinal area occupies in the middle of the wing consid-

[1] One is incorrectly represented on our plate as forked.

[2] Goldenberg gives the breadth as 9 mm. and the proportion as 1 : 2.2; but his enlarged figure, presumably the most accurate, makes the breadth only 7.5.

erably less than one-fourth the width of the wing, and thereafter approaches the costal margin very gradually, terminating, presumably, just before the apical sixth of the wing;[1] in the fragment preserved it emits three longitudinally oblique, straight branches, of which the first is simple, the second simply, and the third doubly forked. The scapular vein is straight, and parallel to the costal margin, lying close beside the mediastinal vein, and, first dividing in the middle of the wing, probably terminates before the tip; its branches, two upon the fragment, are sublongitudinal, at least the first forked. The externomedian vein is strongly arcuate, curving downward to the middle of the inner margin, and emitting eight branches at a wide angle, all of them arcuate, the first nearly longitudinal, the succeeding ones gradually more and more oblique; the first must originate far toward the base of the wing, and does not fork unless near the tip, where it probably does; the next four branches are all forked near the middle of the wing, and probably fork again apically; the lower three are simple, so far as they can be traced, and probably remain so; these branches are more distant than those of the upper part of the wing. The internomedian vein is wanting, but four of its branches (perhaps all there are) can be seen, the outermost forked, the others simple, about as distant as the externomedian branches, very arcuate, and obliquely transverse.

The wing is a small one, the fragment measuring 6.25 mm. in length, and 5.75 mm. in breadth: probably the length of the wing was 13 mm. and the breadth 6 mm., making the breadth to the length as 1 : 2.2. The interspaces, particularly in the internomedian area, are filled with very frequent cross nervules. The fragment is exceedingly imperfect, not more than one-third (a middle piece) of the wing being preserved; but, excepting that it wants the anal furrow, this contains the most important part of the neuration, which differs widely from that of any other cockroach excepting the European species with which we have generically associated it; from this it differs in its presumably greater comparative breadth, the comparative sparseness of the neuration, and the downward curve of all the externomedian branches; the externomedian and scapular veins are also certainly separated much further toward the base, if not altogether, and the distribution of the scapular branches is different.

In my former description of this insect, so different is the neuration from what appears in other American species, I mistook the internomedian for an anal field, and did not attempt to interpret the other parts of the neuration. I also compared it, with no show of reason, to *Etobl. carbonaria*, with which it has no special relationship whatever.

The single specimen known was found at Cossett's pit near Sydney, Cape Breton, by Mr. A. J. Hill, C. E., together with *Libellula carbonaria* Scudd., and a frond of Alethopteris. It was kindly sent me for examination by Principal Dawson, who informs me that it comes from a rather lower horizon than that in which the Cape Breton species of Mylacris occurred, or in the lower part of the middle coal formation near the upper limit of the mill-stone grit. Lower carboniferous.

[1] In the plate, the line which represents the mediastinal vein in the middle of the fragment is unfortunately oblique, as if it were the continuation of the second forked mediastinal branch; instead of parallel to the margin, as it should be.

APPENDIX.

The following species cannot be definitely referred to any of the preceding genera.

Blattina Tischbeini. Pl. 1, fig. 10.

Blattina Tischbeini Gold., Vorw. Faun. Saarbr., 16–17; — Ib., Faun. saraep. foss., i, 16–17, pl. 2, fig. 16; — Ib., Faun. saraep. foss., ii, 19, 51.

Fore wing. The fragment preserved is an insignificant portion of the base, which does not permit us to say more of its affinities than that it belongs to the Blattinariae, and not to the Mylacridae; a network of delicate veins can be seen between the principal nervures.

Hind wing. A much larger fragment of the hind wing is preserved, consisting, however, altogether, or almost altogether, of the anal field fully expanded, but much broken and crushed out of shape, according to Goldenberg; between the veins a very fine transverse neuration is preserved, giving the wing a very delicate appearance.

A fragment of one of the legs is preserved beside the hind wing; a hind leg, according to Goldenberg, consisting of a part of the femur and tibiae "with traces of spines." This is the only palaeozoic cockroach described in which mention is made of spinous legs.

Besides these, upon the same stone but separated from them, is the pronotal shield, which, according to Goldenberg, is transversely elliptical, somewhat gibbous, the hind margin nearly straight; elsewhere, both in front and on the sides, rounded, the surface with some slight cross furrows, its length 8 mm. and its breadth 12 mm. Excepting for its hind margin, its form closely resembles that of *Myl. anthracophilum*.

The species probably attained a length, according to Goldenberg, of 31 mm.

Several specimens were found in a bituminous shale at Hirschbach, near Saarbrücken, Germany. Middle carboniferous.

Blattina latinervis. Pl. 1, fig. 3.

Blattina latinervis Heer, Viertelj. naturf. Gesellsch. Zürich, IX, 288, 296–97, pl., fig. 1; — Gold., Faun. saraep. foss., ii, 20.

This is the best-preserved hind wing of a fossil cockroach known, but is still very fragmentary, nearly the whole anal field (all but a detached fragment), besides the extreme base and a belt across the middle of the wing, being wanting. It is subovate, with a straight or slightly concave costal margin and a rounded apex. The mediastinal vein, if the costal portion of the wing is perfect and correctly represented, runs close to the margin, nearly uniting with it in the middle, and then diverges slightly from it, terminating only a little before the tip, and in its apical half emitting several short, oblique branches. The scapular vein runs parallel to the border in the basal half of the wing, and then divides into two compound branches. The externomedian vein is irregular, forking near the base, the upper branch simple and running in an irregularly arcuate course to the tip of the wing, the other forked doubly, with a similar but less arcuate and more regular course. The internomedian vein emits, close to the base, two or three simple branches. The anal area, to judge from the small detached fragment, is filled with parallel, frequent, gently arcuate veins, united, like those of the other parts of the wing, with rather distant cross veins, forming quadrate cells with the longitudinal veins, and apparently more distant in the anal area than elsewhere. The veins are everywhere edged with black. Length of fragment, 27.5 mm.; breadth, 10 mm.

Heer suggests that this may be the under wing of *Gerabl. clathrata*, but the unusual width of the mediastinal area in the front wing of that species does not harmonize well with the narrowness of the same area in this hind wing; and it is hardly probable that we shall ever be able to determine where it does belong.

A single specimen, from the coal-measures of Manebach, near Ilmenau, Thüringen. Upper carboniferous.

Blattina venosa. Pl. 4, fig. 6.

Blattina venosa Gold., Faun. saraep. foss., ii. 19. 25, 51, pl. 1, fig. 7.

This species is based upon a single fragment from the middle of a wing, whether front or hind can scarcely be determined. Goldenberg says it is of a front wing, but there appears to be no reason for his conclusion. There are a pair of branching veins, the main stems running parallel to each other, and the branches divaricating on opposite sides. Goldenberg says the veins are remarkable for their distinctness, and therefore as he makes no mention of any reticulation or cross venation, there probably is none; the openness of the neuration, with the undeviating course of the branches throughout the rather large fragment, indicate a large species. The two principal veins represented would appear to be the scapular and externomedian: or, perhaps, the externomedian and internomedian. Length of fragment, 18 mm.; breadth, 12 mm.

The single specimen was found in a soft, yellowish shale near Wemmetsweiler, in the neighborhood of Saarbrücken, Germany. Upper carboniferous.

On Pl. 6, figs. 11 and 13, are represented two fragments of wings probably belonging to cockroaches, but of which little more can be said. Fig. 11 comes from Cossett's pit No. 1, at Sydney, Cape Breton, and was found by Col. A. J. Hill; it has no natural border whatever, and may belong to almost any part of the wing; it may perhaps be a portion of an externomedian area, similar to that of *Petrabl. sepulta* (with which it was found), and in that case would probably represent a distinct species. Lower carboniferous.

Fig. 13 probably represents the central portion of a wing, the right hand set of branches belonging to the scapular, the left hand set, which are wrongly represented as connected at base with those of the right hand, then belonging to the externomedian vein. The specimen (No. 2010) came from immediately below vein C at Cannelton, Beaver Co., Penn., and was discovered by Mr. I. F. Mansfield, through whom I received it. It represents a species of perhaps the same size as *Archim. parallelum*, and possibly belongs to it; but as no part of the margin is preserved, any attempt to place it is useless. Lower coal measures of Pennsylvania.

Polyzosterites.

Polyzosterites Gold., Vorw. Faun. Saarb., 18; — Ib., Faun. saraep. foss., i, 18.

Goldenberg defines the genus as consisting of cockroaches in which both sexes are apterous, with nearly semicircular, very slightly marginate pronotum, and a flat, crustacean-like abdomen with sharply edged margin.

Polyzosterites granosus.

Adelophthalmus (Eurypterus) granosus Meyer, Palaeontogr., iv, 8-12, pl. 2, figs. 1, 2.
Eurypterus granosus Salt.-Woodw., Chart foss. Crust., pl. 5, fig. 15.
Polyzosterites granosus Gold., Vorw. Faun. Saarbr., 18;—Ib., Faun. saraep. foss., i, 18, pl. 1, fig. 17;—Ib., Faun. saraep. foss., ii, 20, 51.

Goldenberg describes the species as follows:—

"The pronotum, beneath which, as usually, the head lies concealed, is semi-elliptical, narrowed and rounded anteriorly; its greatest breadth, which falls near the posterior blunt angles, is scarcely less than 28 mm.; the length does not appear to have exceeded 16 mm. The convexity is gentle, and the slightly concave posterior border is accompanied by a feeble margin. The next two thoracic segments have in general a shape similar to that of the succeeding segments of the abdomen. All of them are tumid, not only laterally, but also in front and behind, and bordered with a slender marginal piece, connecting each segment with the preceding. The abdominal and thoracic segments together form a regular oval; the pointed, lobe-shaped outer extremities of the segments become gradually larger and broader toward the extremity of the body, as in living species of Polyzosteria; the last four rings are not so well preserved as the others, and are thrown far out of position, so that the last ventral segment is turned completely around. The thoracic as well as the abdominal segments have the dorsal surface covered with small, crowded tubercles, which are most prominent on the more tumid portions, and by the unaided eye can be seen to be of a blunt, triangular form, directed backward. An entirely similar structure may be seen in what appears to be *Polyzosteria limbata* Burm. Had such an animal been found fossil, it would very likely have been taken for a blind Eurypterus, were it not for the form of the extremity of the abdomen, which in all Eurypteri is linear or linear-lancet shaped."

"This fossil was found in the Eisenbahnschacht near Jägersfreude, in an ironstone nodule. Near Altenwald I found also in such a nodule a similar fossil, but not so completely preserved, which may probably have belonged to another and smaller species of this genus."

Goldenberg figures an articulated fragment found beside the abdomen, and which Meyer, considering the animal as a Eurypterus, had compared to the maxillipeds or false abdominal feet of the modern genus Serolis, but which Goldenberg takes for a Myriopod, like Polyxenus. So far as his illustration goes, it might be taken for the antennae of the insect itself. The form of the last segment indicates a female.

Postscript. November, 1879.—It will not fail of notice how opposed to the drift of this entire essay is the statement of Gerstaecker (Bronn's Klassen und Ordnungen des Thierreichs, v, 292) that the cockroaches described by Germar and Goldenberg from Wettin and Saarbrücken agree in every distinctive family characteristic with those now living ("*stimmen in allen für die betreffenden Familien charakteristischen Merkmalen mit denjenigen der Jetztzeit überein*"). In the same place (p. 291) Gerstaecker remarks that scarcely a single extinct form of cockroach approaches in size the largest living species of the family. Yet, as I have stated, the average size of ancient types may be considered somewhat larger than in modern times.

Gerstaecker (loc. cit. 292, note) considers the wing described by Dohrn under the name of *Fulgora Ebersi* as the hind wing of a cockroach, with most of the anal field destroyed.

It does not, however, agree at all with the structure of the hind wings of palaeozoic cockroaches already known.

Only after the printing of most of this paper have we had access to a paper by Dr. C. J. Andrä (Eine Alge und eine Insectenflügel aus den Steinkohlenformation Belgiens. < Sitzungsb. niederrhein. Gesellsch. Bonn. 1876, 27–28) in which mention is made of the occurrence of the wing of a cockroach in the coal formation of Belgium. The author merely states that an elliptical fragment, representing the margin of a wing, was found, the distribution of the veins in which substantially agreed with that of "Blattina."

Explanation of the Plates.

PLATE II.

All the figures on this plate and the two following are camera lucida copies from other authors; the scale is altered where necessary, so as to be uniformly about two diameters above the natural size; the marks outside the wing represent the limits of the several areas. They all represent European insects. Drawn by the author.

Fig. 1. *Etoblattina anthracophila* (Germ.), p. 64. Copied from Münster's Beiträge zur Petrefactenkunde, v, pl. 13, fig. 3; reversed and the border restored.

Fig. 2. *Etoblattina affinis* (Gold.), p. 62. Copied from the Neues Jahrbuch für Mineralogie, 1869, pl. 3, fig. 3; reversed.

Fig. 3. *Etoblattina carbonaria* (Germ.), p. 73. Copied from Germar's Versteinerungen des Steinkohlengebirges von Wettin, etc., pl. 31, fig. 6[b]; reversed, and the apical margin restored. The scapular area, however, is represented as broader than it should be, and the restored outline is probably too contracted.

Fig. 4. *Etoblattina flabellata* (Germ.), p. 62. Copied from Münster's Beiträge zur Petrefactenkunde, v, pl. 13, fig. 4'; reversed, and the border restored.

Fig. 5. *Etoblattina Dohrnii* Scudd., p. 66. Copied from the Neues Jahrbuch für Mineralogie, 1869, pl. 3, fig. 8, right wing; reversed. The outside mark, representing the termination of the anal area, should be carried one interspace further toward the tip of the wing.

Fig. 6. *Etoblattina russoma* (Gold.), p. 76. Copied from the Neues Jahrbuch für Mineralogie, 1869, pl. 3, fig. 2'; reversed.

Fig. 7. *Etoblattina ? insignis* (Gold.), p. 82. Copied from part of an original drawing received from Dr. Goldenberg, from which pl. 2, fig. 14' of his Fauna saraepontana fossilis, i, was taken. The restored tip is inaccurately represented as fully rounded, whereas it should closely resemble the apex of fig. 9. Cf. pl. 4, fig. 9.

Fig. 8. *Anthracoblattina spectabilis* (Gold.), p. 88. Copied from the Neues Jahrbuch für Mineralogie, 1868, pl. 3, fig. 7; reversed.

Fig. 9. *Etoblattina parvula* (Gold.), p. 81. Copied from the Neues Jahrbuch für Mineralogie, 1869, pl. 3, fig. 6.

Fig. 10. *Etoblattina elongata* Scudd., p. 80. Copied from the Neues Jahrbuch für Mineralogie, 1875, pl. 1, fig. 2; reversed, and with the basal margins restored.

Fig. 11. *Gerablattina Geinitzi* (Gold.), p. 103. Copied from the Neues Jahrbuch für Mineralogie, 1868, pl. 3, fig. 5.

Fig. 12. *Gerablattina Münsterii* Scudd., p. 104. Copied from Germar's Versteinerungen des Steinkohlengebirges von Wettin, etc., pl. 31, fig. 5[b]; the apical margin restored.

Fig. 13. *Etoblattina didyma* (Germ.), p. 75. Copied from Germar's Versteinerungen des Steinkohlengebirges von Wettin, etc., pl. 31, fig. 3; reversed.

Fig. 14. *Etoblattina manebachensis* (Gold.), p. 79. Copied from the Neues Jahrbuch für Mineralogie, 1869, pl. 3, fig. 4.

Fig. 15. *Etoblattina anaglyptica* (Germ.), p. 69. Copied from Germar's Versteinerungen des Steinkohlengebirges von Wettin, etc., pl. 31, fig. 1; reversed, and the apical margin restored. The basal curve of the main veins is not well represented.

Fig. 16. *Etoblattina euglyptica* (Germ.), p. 60. Copied from Germar's Versteinerungen des Steinkohlengebirges von Wettin, etc., pl. 31, fig. 8, with the apical margin restored. Cf. pl. 4, fig. 7.

PLATE III.

See preliminary explanations to Plate II.

Fig. 1. *Gerablattina weissiana* (Gold.), p. 109. Copied from the Neues Jahrbuch für Mineralogie, 1868, pl. 3, fig. 10; with part of the inner border restored. The outside mark, indicating the lower limit of the externomedian area is placed much too far from the tip of the wing; there should be also a single branch to the internomedian vein.

Fig. 2. *Gerablattina producta* Scudd., p. 106. Copied from the Neues Jahrbuch für Mineralogie, 1868, pl. 3, fig. 9; reversed.

Fig. 3. *Gerablattina scaberata* (Gold.), p. 102. Copied from Goldenberg's Fauna saraepontana fossilis, ii, pl. 1, fig 8; reversed. The branch of the externomedian vein, being conjectural, should have been dotted throughout.

Fig. 4. *Gerablattina clathrata* (Heer), p. 100. Copied from the Vierteljahrsschrift der naturforschenden Gesellschaft, Zürich. IX, pl., fig. 3; with the inner and apical margin restored. This figure accidentally represents the wing as magnified a little less than two diameters.

Fig. 5. *Etoblattina lebachensis* (Gold.), p. 59. Copied from Goldenberg's Fauna saraepontana fossilis, i, pl. 2, fig. 15; reversed.

Fig. 6. *Gerablattina Germari* (Gieb.), p. 107. Copied from Germar's Versteinerungen des Steinkohlengebirges von Wettin, pl. 31, fig 9.

Fig. 7. *Etoblattina primaeva* (Gold.), p. 58. Copied from Palaeontographica, IV, pl. 3, fig. 1[a].

Fig. 8. *Etoblattina mantidioides* (Gold.), p. 72. Copied from the Geological Magazine, IV, pl. 17, fig. 6. The restored outline of the apical half of the wing is undoubtedly incorrect, and the inner margin of the base is represented as much too convex; a corrected figure will be found in the text, p. 73; the outside mark indicating the lower limit of the scapular area should be removed to the apex of the wing.

Fig. 9. *Etoblattina leptophlebica* (Gold.), p. 77. Copied from the Neues Jahrbuch für Mineralogie, 1869, pl. 3, fig. 1[a]; reversed, and with the apical margin restored.

Fig. 10. *Progonoblattina helvetica* (Heer), p. 119. Copied from the Vierteljahrsschrift der naturforschenden Gesellschaft, Zürich, IX, pl., fig. 1.

Fig. 11. *Gerablattina intermedia* (Gold.), p. 101. Copied from Goldenberg's Fauna saraepontana fossilis, ii, pl. 1, fig. 10; reversed.

Fig. 12. *Progonoblattina Fritschii* (Heer), p. 120. Copied from the Vierteljahrsschrift der naturforschenden Gesellschaft, Zürich, IX, pl., fig. 2; with the apical margin restored.

Fig. 13. *Gerablattina Goldenbergi* (Mahr), p. 98. Copied from the Neues Jahrbuch für Mineralogie, 1870, p. 284, fig. 1; with the apical margin restored.

Fig. 14. *Gerablattina Mahri* (Gold.), p. 108. Copied from the Neues Jahrbuch für Mineralogie, 1870, p. 284, fig. 2[a]; with the basal and apical margins restored.

PLATE IV.

See preliminary explanations to Plate II.

Fig. 1. *Anthracoblattina Rückerti* (Gold.), p. 96. Copied from the Neues Jahrbuch für Mineralogie, 1868, pl. 3, fig. 11; with most of the border restored; probably this represents the wing as broader than it should be.

Fig. 2. *Anthracoblattina Remigii* (Dohrn), p. 95. Copied from Palaeontographica, XVI, pl. 8, fig. 3, with the inner and apical margins restored.

Fig. 3. *Blattina latinervis* Heer, p. 127. Copied from the Vierteljahrsschrift der naturforschenden Gesellschaft, Zürich, IX, pl., fig 4[b].

Fig. 4. *Petrablattina gracilis* (Gold.), p. 124. Copied from Palaeontographica, IV, pl. 3, fig. 3^{a}; reversed. One of the middle anal veins is wrongly represented as forked.

Fig. 5. *Anthracoblattina porrecta* (Gein.), p. 93. Copied from the Neues Jahrbuch für Mineralogie, 1875, pl. 1, fig. 4.

Fig. 6. *Blattina venosa* Gold., p. 128. Copied from Goldenberg's Fauna saraepontana fossilis, ii, pl. 1, fig. 7.

Fig. 7. *Etoblattina euglyptica* (Germ.), p. 60. Copied from Germar's Versteinerungen des Steinkohlengebirges von Wettin, etc., pl. 31, fig. 7^{b} (pars). Hind wing; cf. pl. 2, fig. 16.

Fig. 8. *Anthracoblattina sopita* Scudd., p. 89. Copied from the Neues Jahrbuch für Mineralogie, 1875, pl. 1, fig. 1, left wing.

Fig. 9. *Etoblattina? insignis* (Gold.), p. 82. Copied from part of an original drawing received from Dr. Goldenberg, from which pl. 2, fig. 11^{a} of his Fauna saraepontana fossilis, i, was taken. Hind wing; cf. pl. 2, fig. 7.

Fig. 10. *Blattina Tischbeini* Gold., p. 127. Copied from Goldenberg's Fauna saraepontana fossilis, i, pl. 2, fig. 16^{c}.

Fig. 11. *Hermatoblattina lebachensis* (Gold.), p. 117. Copied from Palaeontographica, IV, pl. 6, fig. 7; with the apical margin restored.

Fig. 12. *Anthracoblattina winteriana* (Gold.), p. 94. Copied from the Neues Jahrbuch für Mineralogie, 1870, p. 288, fig. 2; with the basal margins restored. The figure is probably too small; see p. 95.

Fig. 13. *Oryctoblattina reticulata* (Germ.), p. 122. Copied from Germar's Versteinerungen des Steinkohlengebirges von Wettin, etc., pl. 39, fig. 15^{b}; with the apical margin restored.

Fig. 14. *Hermatoblattina wemmetsweileriensis* (Gold.), p. 115. Copied from Goldenberg's Fauna saraepontana fossilis, ii, pl. 1, fig. 9; reversed. The costal margin is a little too full.

PLATE V.

All the figures on this plate are original, and represent American insects. They were drawn on stone by L. Trouvelot.

Fig. 1. *Mylacris bretonense* (Scudd.), p. 41. Magn. $\frac{3}{1}$; drawn by S. H. Scudder.

Fig. 2. *Lithomylacris angustum* Scudd., p. 48. Magn. $\frac{2}{1}$; drawn by J. H. Emerton.

Fig. 3. *Lithomylacris angustum* Scudd., p. 48. Magn. $\frac{1}{1}$; drawn by J. H. Emerton.

Fig. 4. *Lithomylacris pittstonianum* Scudd., p. 50. Magn. $\frac{2}{1}$; drawn by J. H. Emerton.

Fig. 5. *Lithomylacris simplex* Scudd., p. 51. Magn. $\frac{5}{2}$; drawn by S. H. Scudder.

Fig. 6. *Mylacris anthracophilum* Scudd., p. 45. Magn. $\frac{2}{1}$; drawn by S. H. Scudder.

Fig. 7. *Mylacris anthracophilum* Scudd., p. 46. Magn. $\frac{1}{1}$; drawn by J. H. Emerton. Pronotum.

Fig. 8. *Mylacris anthracophilum* Scudd., p. 45. Magn. $\frac{1}{1}$; drawn by J. H. Emerton.

Fig. 9. *Necymylacris heros* Scudd., p. 54. Magn. $\frac{2}{1}$; drawn by J. H. Emerton. The first (inferior) offshoot of the first scapular branch should be forked near the tip, or directly opposite the extremity of the first branch itself.

Fig. 10. *Lithomylacris pittstonianum* Scudd., p. 50. Magn. $\frac{1}{1}$; drawn by J. H. Emerton.

Fig. 11. *Mylacris Heeri* (Scudd.), p. 43. Magn. $\frac{2}{1}$; drawn by S. H. Scudder. The uppermost fork of the apical branch of the internomedian vein is not sufficiently longitudinal.

Fig. 12. *Necymylacris lacoanum* Scudd., p. 53. Magn. $\frac{3}{1}$; drawn by J. H. Emerton.

Fig. 13. *Mylacris pennsylvanicum* Scudd., p. 41. Magn. $\frac{1}{1}$; drawn by J. H. Emerton. See note to next figure.

Fig. 14. *Mylacris pennsylvanicum* Scudd., p. 44. Magn. $\frac{2}{1}$; drawn by J. H. Emerton. The mediastinal branch next the humeral lobe should have been omitted from this and the preceding figure; it does not exist. The restored outline of the wing probably extends too far outward.

Fig. 15. *Mylacris Mansfieldi* Scudd., p. 47. Magn. $\frac{3}{1}$; drawn by J. H. Emerton.

PLATE VI.

Excepting fig. 5, all the drawings on this plate are original, and represent American insects. They were put on stone by L. Trouvelot.

Fig. 1. *Gerablattina fascigera* (Scudd.), p. 113. Magn. $\frac{2}{1}$; drawn by J. H. Blake. The base of the

externomedian vein should have been represented as united at the base with the scapular vein; the outside mark indicating the end of the scapular area is placed slightly too high; that indicating the end of the anal area is placed on the wrong side of the anal furrow.

Fig. 2. *Gerablattina fascigera* (Scudd.), p. 113. Magn. [illegible]; drawn by J. H. Blake.

Fig. 3. *Etoblattina Lesquereuxi* Scudd., p. 67. Magn. [illegible]; drawn by J. H. Emerton. See note to next figure.

Fig. 4. *Etoblattina Lesquereuxi* Scudd., p. 67. Magn. [illegible]; drawn by J. H. Emerton. One or two basal branches of the mediastinal vein are not shown. The origin of the middle externomedian branch is wrongly represented; see a corrected figure of the latter in the text, p. 68.

Fig. 5. *Etoblattina weissigensis* (Germ.), p. 65. Copied from the Neues Jahrbuch für Mineralogie, 1873, pl. 3, fig. 1; reversed. Camera lucida sketch by S. H. Scudder. This is a European species.

Fig. 6. *Archimylacris parallelum* Scudd., p. 85. Magn. [illegible]; drawn by J. H. Emerton. The mediastinal vein of the front wing should be represented as gradually approaching the costal margin in the basal half of the wing. The mediastinal vein of the hind wing can be seen on the specimen, underlying the front wing, but is not represented on the plate. The wing is accompanied by the pronotum.

Fig. 7. *Petrablattina sepulta* (Scudd.), p. 125. Magn. [illegible]; drawn by S. H. Scudder. The inner margin of the fragment is represented as more convex than it should be; the short line representing the main mediastinal line in the middle of the fragment should be nearly parallel to the margin, not oblique.

Fig. 8. *Archimylacris acadicum* Scudd., p. 81. Magn. [illegible]; drawn by S. H. Scudder. The middle internomedian branches are given too sinuous a curve.

Fig. 9. *Gerablattina balteata* Scudd., p. 110. Magn. [illegible]; drawn by J. H. Blake. The terminal part of the internomedian vein, as described in the text, is not shown here; the outside mark indicating the outer termination of the internomedian area should be considerably nearer the tip of the wing.

Fig. 10. *Gerablattina balteata* Scudd., p. 112. Magn. [illegible]; drawn by L. Trouvelot. Represents the anal area only.

Fig. 11. Fragment of the wing of a cockroach from Sydney, Cape Breton; p. 128.

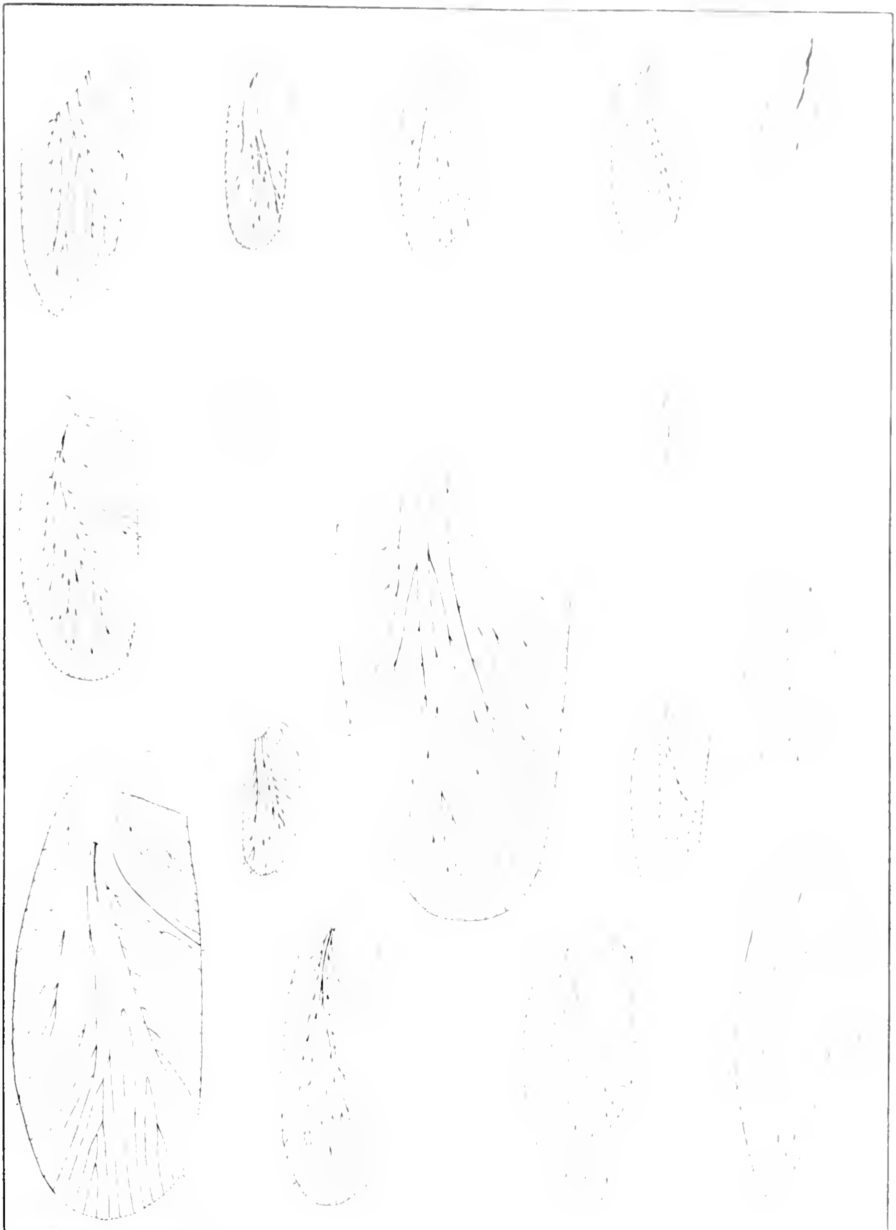
Fig. 12. *Etoblattina venusta* (Lesq.), p. 70. Magn. [illegible]; drawn by J. H. Blake. The restored outline of the base of the wing very probably represents too much as lost.

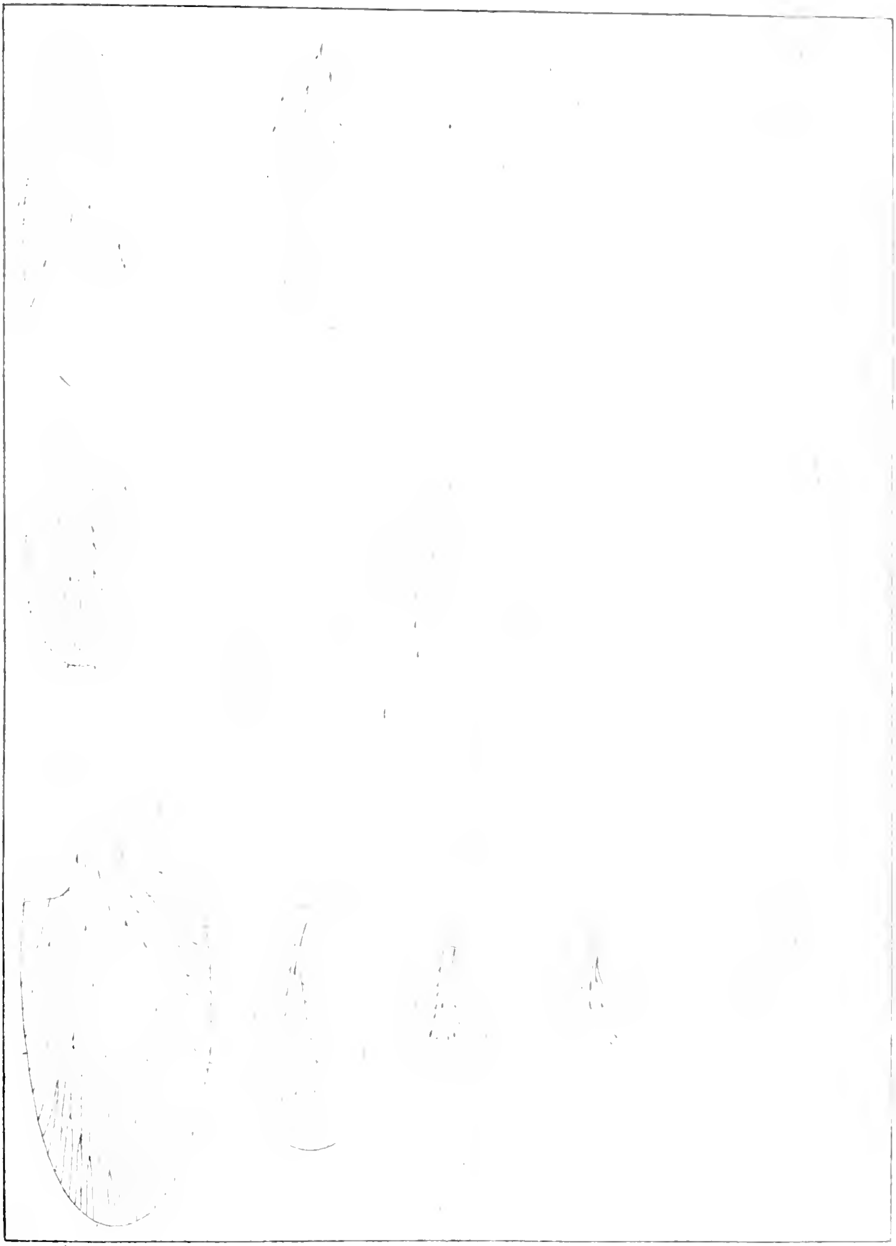
Fig. 13. Fragment of the central portion of the wing of a cockroach from Cannelton, Penn.; p. 128.

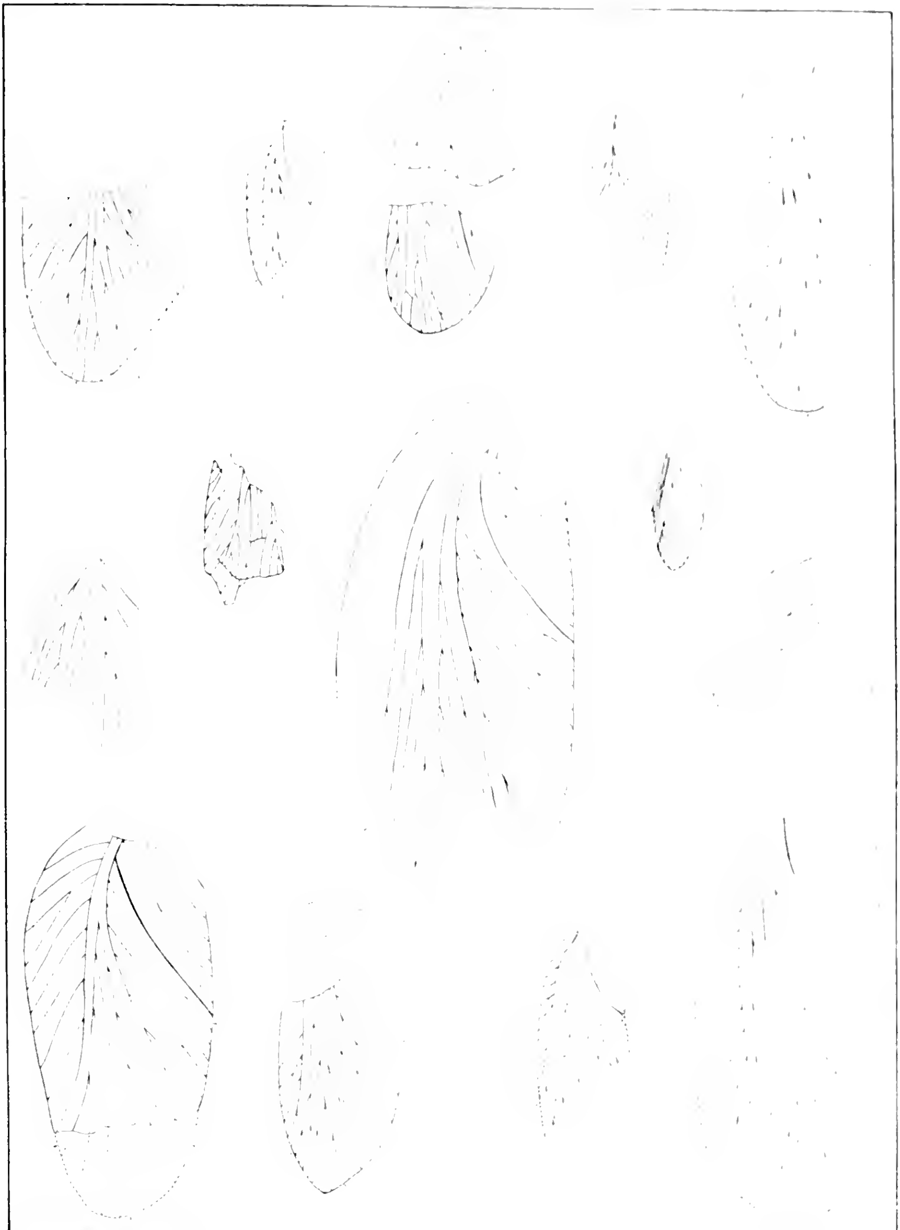
Fig. 14. *Archimylacris acadicum* Scudd., p. 84. Magn. [illegible]; drawn by S. H. Scudder.

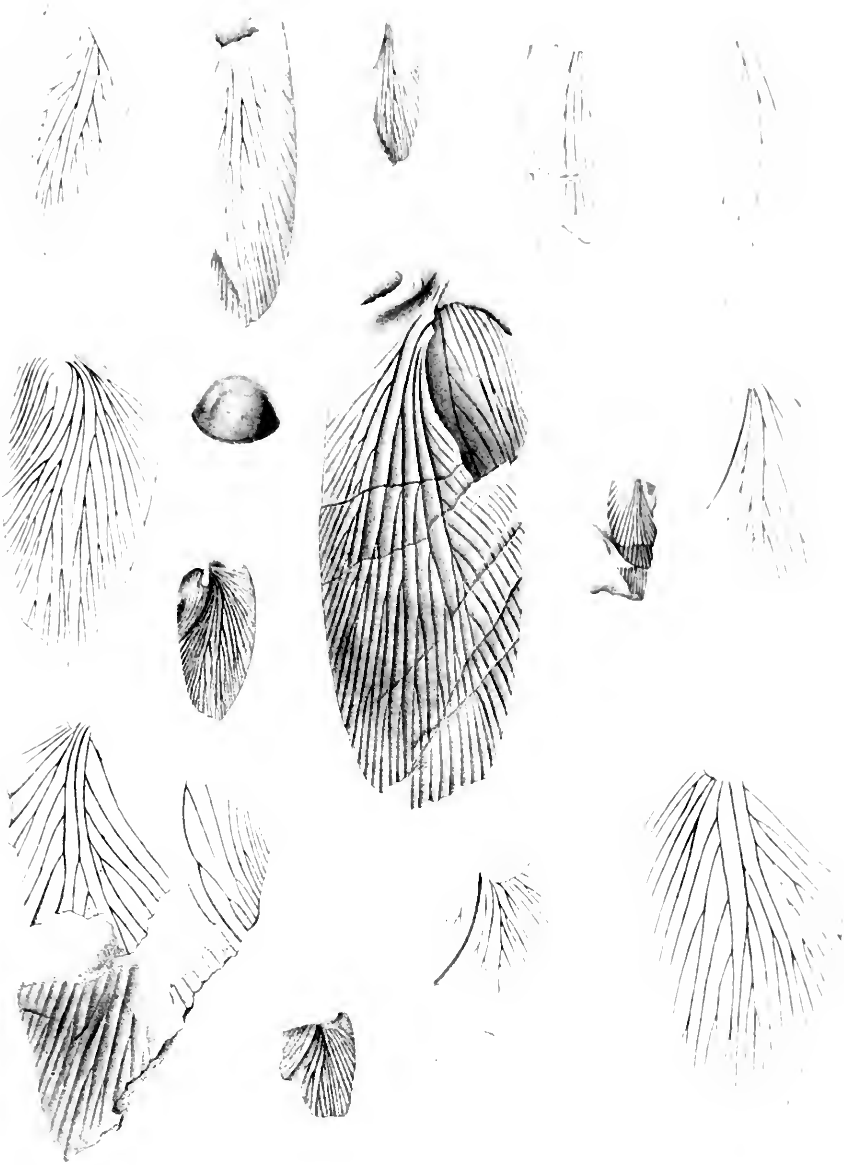
Index of Species.

The date of presentation of this paper to the Society (May 7, 1879) was accidentally omitted from the title.









IV. New and Interesting Hydroids from Chesapeake Bay.

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Communicated Jan. 19, 1881.

While connected with the Chesapeake Zoological Laboratory in the summer of 1879 I had opportunities for studying some of the Hydroids of Chesapeake Bay. During the early part of the summer we were stationed at Crisfield, Maryland, and later at Fort Wool, Virginia. Again this summer I have had opportunities for work at Fort Wool and continued the studies begun there in 1879. My time was too limited to permit of more extended work on the hydroids although there was a great supply of new and attractive material. It will be noticed that all of the six forms described are of the gymnoblastic group; all but one are new species and for one of them a new genus has been established.

The most interesting of the six forms is *Stylactis arge,* which has the remarkable habit of dividing its hydranths by a transverse partition, leaving the distal half free, which latter with its two or three hydrorhizal processes that are developed before the division takes place, floats away free, being carried about by currents; finally it settles down, becomes attached and by growth and budding gives rise to a new colony. It is another method, in which the hydroids are already so rich, by virtue of which they increase their numbers and their geographical distribution. A second interesting feature of this species is the fact that the gonophores in the female are quite highly developed, having radial and circular canals and may or may not become free.

Calyptospadix is another interesting hydroid, especially in its hydrotheca-like processes of perisarc, which are more like the genuine hydrothecae of the Calyptoblasts than any thing else known among the Gymnoblastea. The species here described are

Calyptospadix cerulea, gen. et sp. nov.
Eudendrium carneum, sp. nov.
Stylactis arge, sp. nov.
Lovenella gracilis, sp. nov.
Bougainvillia rugosa, sp. nov.
Hydractinia echinata Fleming.

Calyptospadix gen. nov.[1]

Trophosome. Hydrophyton consisting of a branching hydrocaulus rooted by a creeping, filiform hydrorhiza. Hydranths fusiform with filiform tentacles which are arranged in a single verticil round the base of a conical hypostome. Perisarc developed into large hydrotheca-like processes.

Gonosome. Sporosacs developed on the ultimate ramuli beneath the terminal hydranths.

Calyptospadix cerulea nov. sp. Plate 7, figs. 1 to 9.

Trophosome. Hydrocaulus simple, not much branched, of equal size throughout and attaining a height of three to four inches; branches irregularly arranged upon all sides of the stem; those of the proximal third of the hydrocaulus are very short, while those of the remaining portions are the longest in the colony, some of them being half the length of the main stem; branchlets arranged alternately; hydranths fusiform with a conical proboscis and eight to ten, occasionally twelve, tentacles, the latter arranged in a single verticil, protected by cup-shaped processes of the perisarc, roughened exteriorly by circular ridges and which very nearly cover the entire hydranth when it is fully retracted; perisarc annulated at the bases of the branches and branchlets. Gonosome. Sporosacs developed in clusters of from three to five on the ultimate ramuli just beneath the hydrotheca-like expansions; a large number of planulae developed in each female sporosac, the spadix unusually large.

Color. The female gonophores, the ova, and the planulae in their earlier stages, bright blue.

Development of gonosome. July and August.

Bathymetrical distribution. Littoral and coralline zones.

Habitat. Spiles of wharf and old shells.

Locality. Fort Wool, Virginia.

It is very interesting to notice the approximation to the calyptoblastic forms indicated in this species, shown by the hydrothecae, which are of fully as much protection to the hydranths as are the slightly developed hydrothecae of many species of Halecium. The reproductive zooids have a perfect chitinous covering, but it is developed around a sporosac and so is not a gonangium according to Allman. This author states that a gonangium is developed about a blastostyle. His definition of the Calyptoblastea is, "A sub-order of Hydroida in which an external protective receptacle (hydrotheca or gonangium) invests either the nutritive or generative buds." According to this, any hydroid having hydrothecae or gonangia belongs to this suborder, and as this species possesses developments of perisarc, which are so much like hydrothecae that there is only an artificial, no natural, distinction, it follows that we are dealing with a form that stands very close indeed to the sub-order Calyptoblastea of Allman.

[1] From καλυπτός, covered, and spadix, the hollow process in a sporosac about which the generative elements are developed.

Eudendrium carneum, nov. sp. Plate 7, figs. 10 to 17.

Trophosome. Hydrocaulus much branched, fascicled at its base and attaining a height of 75 to 125 mm.; primary branches irregularly arranged on all sides of the hydrocaulus, occasionally some of the branches near the base very large, being little less than the main stem; the secondary branches or branchlets arranged alternately on the upper side of the branches; hydranths supported at the summits of small ramuli borne on opposing sides of the branchlets and also at the extremities of the branches, branchlets and ramuli; perisarc firm, nearly colorless at the distal ends, deepening to a dark brown at the base, annulated at the bases of the branches, branchlets and ramuli. Hydranths large and usually with about twenty-four tentacles.

Gonosome. Sporosacs in the male, composed of a number of spherical receptacles arranged in a moniliform series of from three to five and borne in a crowded verticil. Sporosacs in the female arranged in irregular, elongated groups of three to six, several of which spring from one side of a branchlet or a ramulus; the distal end of the ramulus may or may not support a hydranth, each sporosac ornamented by a thickening of the perisarc which leaves only the distal portion thin; this latter part finally breaks away, forming a means of exit for the planula. The different sexes are usually found in different colonies.

Color. Hydranths vermillion, perisarc darkest in oldest parts; female gonophores red, planulae red, male gonophores red.

Habitat. Attached to spiles of wharves, rocks and shells, in the littoral and coralline zones.

Locality. Fort Wool, Virginia, in the entrance to Hampton Roads.

The rocks forming the piers and also the spiles of the old wharf at Fort Wool are coated during June, July and August with immense quantities of these showy colonies that form a miniature forest, extending at low tide as far as the eye can reach. The lower parts of the colonies form dense tangled masses all matted together with thick growths of Perophora, two or three kinds of sponges, Vesicularia, various forms of Vorticellidae, etc., etc.

The arrangement of the branches and consequently the forms of the colonies vary much according to the surrounding conditions; if the colony is not restricted the branches diverge from all sides and give a full, well-rounded growth about the main stem; but they are often so crowded that the branches are twisted and bent round into one plane, looking as though they all sprung from two sides of the stem. I succeeded in raising a number of colonies from the eggs; the eggs passed into the planula stage, these became free-swimming, finally they resorbed their cilia, became attached, and developing a hydranth and hydrorhiza, with a covering of perisarc, began the formation of a new colony.

One of the many planulae observed, developed after becoming attached, two hydranths at once; the two trending away from each other in nearly opposite directions, see Plate 7, fig. 14. So many planulae were developing at the same time that the clear glass dish became dotted all over with bright rosy spots where they had attached themselves.

Sytlactis arge, nov. sp. Plate 8, figs. 18 to 20.

Trophosome. Hydrocaulus undeveloped; hydranths with very much elongated, slender bodies, occurring in colonies of ten to thirty tentacles, arranged in two verticils below the hypostome, from six to eight in each circlet, those of the lower circlet sometimes shorter than those of the upper one; hypostome large and rounded at the distal extremity.

Gonosome. Sporosacs developed on the bodies of the hydranths beneath the tentacles; two are first developed from opposite points on the hydranth and then two others, also opposite one another and on different sides of the hydranth from the first pair, make their appearance; the gonophores are quite well developed, having a large cavity, and four radial canals connected distally by a peripheral canal; slight processes project from the rim of the bell, which appear to be rudimentary tentacles; a large number of planulae developed in each female gonophore and these may be liberated while it is attached or after it becomes free; if the planulae are liberated while the gonophore is attached, the latter never becomes free, but in many cases the gonophore becomes freed from the hydranth and with its freight of planulae leads a free-swimming life.

Color. The entire colony a delicate opaque white.

Development of gonosome. June and July.

Habitat. On stems of *Zostera marinum*.

Locality. Crisfield, Maryland, on the Chesapeake Bay.

I became very much interested in this hydroid after seeing under the microscope a gonophore detach itself from the hydranth on which it had developed and swim away free. It accomplished this by a considerable number of very energetic, convulsive contractions, which were sufficiently violent to rupture its peduncle. I had often seen the planulae discharged from the attached gonophores and was much surprised to see in a number of cases, and where the specific identity of the different colonies was undoubted, that the gonophores with their contained planulae became detached.

Another remarkable habit possessed by this species consists in the detachment of the distal portion of a hydranth, which settles down in some new locality and gives rise to a new colony. This takes place in this way: a constriction appears around the body of a hydranth; from a point just above which two or three cylindrical processes are developed which are to serve as a hydrorhiza to the new colony; the constriction then becomes complete and this short-bodied hydranth is carried by the currents to a considerable distance, perhaps, before it attaches itself by means of its hydrorhiza, when by growth and budding it soon forms new colonies.

This method of multiplying colonies and of planting them in new and possibly distant places is a new feature in the hydroids. In Schizocladium there is an approach to this same thing, but even in that case the method is distinctly different.

In the possession of gonophores which may or may not become free, we are reminded of the *Syncoryne mirabilis* of L. Agassiz, and the facts in this case lend support to the characters claimed for *S. mirabilis*. I greatly regret that my investigations upon this interesting form were so suddenly terminated. I was obliged to leave the locality where this species is found at a few hours notice, and have never found an opportunity to continue my work there. I was anxious to obtain a more detailed knowledge of the structure of the gonophores and to make out if there were any differences between the attached and the free forms. To its interest scientifically it adds the attraction of beauty, for it is one of the most graceful and beautiful hydroids I have ever seen.

Lovenella gracilis, nov. sp. Plate 9, figs. 25 to 39.

Trophosome. Hydrocaulus very slender, sparingly branched, with one or two annulations at the base of each branch and hydrotheca, divided by transverse septa into numerous short segments, three between each two hydrothecae; branches simple and similarly divided as the main stem; hydrothecae arranged alternately on the stem and branches, hyaline, rather stout, the length not more than twice the breadth, closed at the top by a conical operculum usually consisting of eight pieces; hydranths large and active with a single verticil of ten or twelve tentacles and a large prominent proboscis.

Gonosome. Gonangia developed from the bases of the hydrothecal peduncles, very long and slender, largest at distal end and tapering toward the base, supported on short pedicils consisting of one to three annulations; from three to five planoblasts developed in each gonangium, aperture terminal.

Planoblasts, twenty-four hours after liberation round and somewhat flattened in outline, microscopic in size; radial canals four, connected by a circumferential canal at the periphery; marginal tentacles six, of which two are very large, situated at the peripheral extremities of two opposite chymiferous tubes, the four smaller tentacles disposed one on either side of each of the large ones; at the points on the margin of the bell where the other two chymiferous tubes join the peripheral canal there are rounded processes which have the appearance of rudimentary tentacles, as yet undeveloped; lithocysts four in number and located midway between the points where each two adjoining chymiferous tubes connect with the circumferential tube; the tentacles and the entire surface of the bell are well supplied with nematocysts.

Until we have a more complete knowledge of the *Lovenella clausa* of Loven and Hincks, it is a question of doubtful issue as to the relationships and systematic position of this species. The genus Lovenella as characterized by Hincks is distinguished from its allies by the possession of elongated, turbinate hydrothecae, crowned with a distinct conical operculum composed of many convergent segments; polypites with a large and prominent proboscis. Reproduction unknown. The species *L. clausa* has a habit of growth very similar to that of *L. gracilis*, the opercula of the hydrothecae are usually of eight segments in both species, the tentacles are of about the same number and they both possess the same style of large prominent proboscis. From these various points of similarity I consider it better to put this new form in this genus rather than to create a new one for it. When the reproduction of *L. clausa* has been made out we shall have an opportunity of deciding the true relations of these two forms.

The form of the hydrothecae are similar to those of Leptoscyphus and also those of some species of Campanulina, but from the characters of both gonosome and trophosome, *L. gracilis* can have no genetic relationships with either of these From a study of the growing colony it was determined that terminal growth takes place by the development of a lateral bud from a point on the terminal segment just below the annulated pedicel of the terminal hydranth; as this process elongates it is divided by four septa into four segments, from the distal one of which a new hydranth is formed, so that each hydranth on the main stem has in turn been the terminal zooid of the colony. From the series of figures 29 to 34 on Plate 9 some idea may be obtained of the rate of growth in the hydrocaulus of this species: figure 30 was taken eight hours subsequently to figure 28; figure 31 six hours later; figure 32 seven hours afterward; figure 33 after a lapse of four hours and figure 34 seventeen hours after figure 31 or forty-two hours later than figure 33. I also recorded the rate of growth in the hydrorhiza which is indicated in Plate 9 figures 27 and 28; the latter figure being made thirty-two hours after the other one. It should be remembered that the colony upon which these observations were made was in somewhat abnormal conditions. My specimens were procured from a depth of three to ten fathoms where the temperature was considerably below that of the atmosphere. I was unable to have them in an aquarium with a constant stream running through, and the water being changed but a few times during the day the specimens must have been subjected to a much higher temperature than they are generally accustomed to. It is possible moreover that a more, rather than a less rapid growth may have thus been induced, as it is well known that many hydroid colonies, especially of the Calyptoblastea, will, when stimulated by impure water in aquaria, develop long, slender processes at a very rapid rate. They seem to be endeavoring to get into a region where better conditions for their welfare exist.

Bougainvillea rugosa, nov sp. Plate 8, figs. 21 to 24.

Trophosome. Hydrocaulus large and compound at the base, tapering to the distal end where it becomes simple, rooted by creeping stolons and attaining a height of three inches; branches numerous, irregularly arranged, a few that arise from near the proximal end of the main stem nearly equal the latter in length; most of the branches are short and delicate, bearing small branchlets which give origin to three or four ultimate ramuli; hydranths fusiform with a rather small, conical hypostome, protected by an expansion of the perisarc very much roughened by circular ridges, into which the hydranths are partially retractile; tentacles short and eight to ten in number.

Gonosome. Planoblasts borne by the hydrocaulus on the ultimate ramuli below the hydranths, having at the time of liberation a deep umbrella, somewhat pyriform; hypostome short and thick, chymiferous tubes four with circular canals, proboscidial tentacles four, capitate, unbranched, marginal tentacles twelve, three of equal size at extremity of each radial canal, where they originate from a common highly colored bulb; ocelli developed at the bases of those two tentacles of each group which become first and second as one passes round the bell from left to right; with increased age they gain in size and the tentacles become elongated but they show no indications of developing other tentacles or of producing ocelli at the bases of the third tentacles.

Color. The colonies are light brown.

Bathymetrical distribution. Laminarian zone.

Development of gonosome. August and September.

Habitat. Growing in large colonies on Alcyonidium.

Locality. Hampton Roads, lower parts of Chesapeake Bay.

The best diagnostic characters of this species are found in the shape of the planoblast and the number of marginal tentacles. All other species of Bougainvillea have primarily but two marginal tentacles in each group. It is very possible of course that the labial tentacles become branched and the marginal tentacles increase in number when they are in a state of nature, but as already remarked they developed no indications of such a change after living in my aquaria for a number of days. The absence of an ocellus from the base of one tentacle of each group is also anomalous.

Hydractinia echinata Fleming. Plate 9, fig. 40.

Some of the outer spiles of the wharf at Fort Wool were completely covered from low-water mark to the bottom with a delicate moss-like growth of a milk-white color, which upon close inspection proved to be colonies of this delicate hydroid. I tried in vain to find any mouths to the blastostyles and finding also that the two circlets of tentacles are of quite different lengths, I concluded that they were specimens of *H. echinata* and not the *H. polyclina* of Agassiz, although from their habitat and locality one would expect that they might be the latter.

I was unable to find any of the capitate, spiral zooids, but found a great many of the simple, tentacular forms described by Wright and Hincks. Among these I noticed one interesting zooid that in its long, slender form was quite like the others, but was provided with an enlarged hollow portion at its distal extremity surmounted by a conical or rounded hypostome and a circlet of tentacles. I was unable to detect any mouth in the hypostome though I spent a number of hours in the attempt. The tentacles were not fully developed; some of them, five of the nine, being only rudimentary while the other four were a little more than twice the length of the short hypostome and of equal size.

It is worthy of notice that this form is intermediate between the ordinary tentacular zooid and the normal feeding polypite, and thus offers an explanation of the origin of the tentacular members of the colony.

From the fact that these forms have been noticed by Wright, Hincks and myself, and from their existing in such considerable numbers in the colonies found at Fort Wool, I am led to believe that the tentacular zooids are regular, normal members of the colony and not abnormal forms as suggested by Allman.

A peculiar, evidently abnormal form of the feeding polypite I also noticed; the body was in a greatly swollen condition and remained as represented in figure 40 during the three days that it was under observation.

[1] A Monograph of the Gymnoblastic Hydroids. By J. Allman, F.R.S., etc. Vol. II, p. 346.

Explanation of Plates.

PLATE VII.

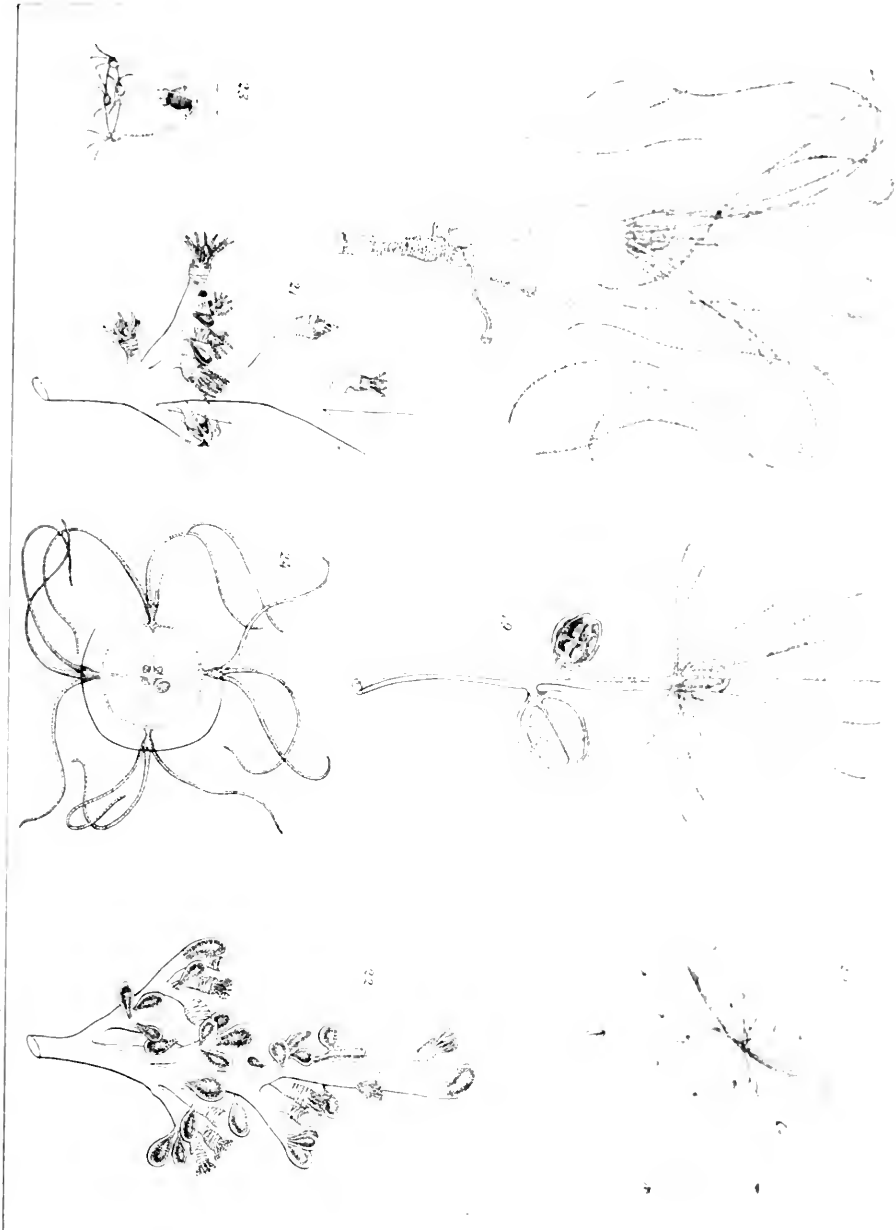
1. *Calyptospadix cerulea*, ×25, portion of a branch.
2. The same, ×25, portion of the main stem.
3, 4. The same, ×25, portions of branches.
5. The same, ×25, male sporosacs; *a*, spadix.
6. The same, ×25, female sporosacs.
7. The same, ×80, a female sporosac, *a*, the large spadix.
8. The same, ×80, a female sporosac, side view, *a*, spadix.
9. The same, ×80, a female sporosac, *a*, spadix; *b*, developing ova.
10. *Eudendrium carneum*, ×25, portions of branches, *a*, a young hydranth.
11. The same, ×25, a large terminal hydranth.
12. The same, ×80, female sporosacs.
13. The same, ×25, female sporosacs.
14. The same, ×25, an abnormal twin planula or two hydranths developing simultaneously from one planula.
15. The same, ×80, a normal planula.
16. The same, ×25, a normal planula.
17. The same, ×25, a branch with male sporosacs.

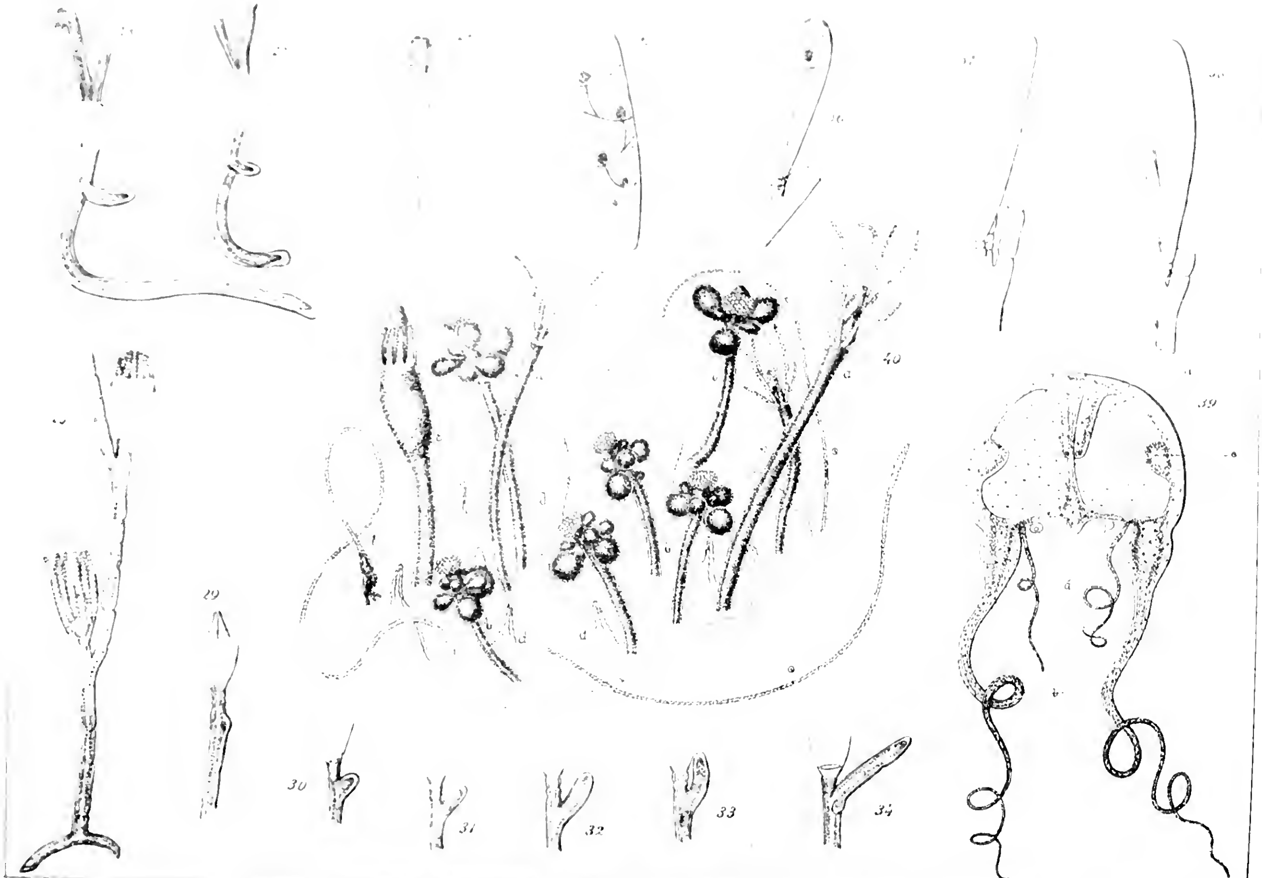
PLATE VIII.

18. *Stylactis arge*, ×25, an adult hydranth; *a*, constriction in stem; *b*, *b*, hydrorhizal growths by which the hydranth will attach itself after becoming free.
19. The same, ×25, a hydranth with female medusoids.
20. The same, ×$\frac{2}{3}$, a colony.
21. *Bougainvillea rugosa*, ×25, a portion of a branch with hydranths and sporosacs.
22. The same, ×25, portion of main stem with hydranths and sporosacs.
23. The gonocheme of the same, ×80.
24. The same individual gonocheme two days later, ×80; showing the great increase of the tentacles in length but no addition to their number. The oval, granular mass that has become separated from the manubrium I do not understand; it may be abnormal.

PLATE IX.

25. *Lovenella gracilis*, ×25, portion of main stem and hydrorhiza.
26. The same, ×25, a hydranth expanded.
27. The same, ×25, the hydrorhiza.
28. The same, ×25, the hydrorhiza thirty-two hours later.
29. The same, ×25, terminal portion of stem with lateral bud, the latter to form the next internode of the stem.
30. The same portion, ×25, eight hours later.
31. The same portion, ×25, six hours later.
32. The same portion, ×25, seven hours later.
33. The same portion, ×25, four hours later.
34. The same portion, ×25, seventeen hours later.
35. The same, ×25, female gonangium with developing blastochemes.
36. The same, ×25, gonangium.
37. The same, ×25, gonangium.
38. The same, ×25, gonangium and hydrotheca.
39. The same, ×80, blastocheme; *a*, lithocysts, *b*, marginal tentacles, *c*, sporosacs, *d*, manubrium.
40. *Hydractinia echinata*, *a*, feeding zooids, *b*, reproductive zooids, *c*, tentacular zooids, *d*, chitinous spines, *e*, an abnormal form of feeding zooid, *f*, an abnormal tentacular zooid.

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V. Archipolypoda, a Subordinal Type of Spined Myriapods from the Carboniferous Formation. By Samuel H. Scudder.

Read January 5, 1881.

All the paleozoic myriapods which have been published, only fifteen nominal species in all, have been referred to the Diplopoda or Chilognatha as they are variously termed. Among them are species which seem to bear a very close general resemblance to modern Iulidae, and some of them have even been described under the generic name Iulus. Others, however, first made known as myriapods by Messrs. Meek and Worthen in 1868, in the Proceedings of the Philadelphia Academy of Natural Sciences, and in the same year figured in the third volume of the reports of the Illinois Geological Survey, differ strikingly from modern types in the presence of rows of very large forked and branching spines upon the surface of the body. These naturalists were able also to show the probability that a fossil from the coal measures of England which Mr. Salter had referred to the crustacean genus Eurypterus belonged in the same group, and more recently Mr. Henry Woodward has pointed out that not only this form, but another, known since the publication of Brodie's work on the English Fossil Insects in 1845, and which was supposed by Westwood to be the larva of Saturnia, a genus of Lepidoptera, should certainly be referred to this group of spiny myriapods; and to the list Woodward has also added another species.

Having enjoyed the opportunity, through the kindness of Messrs Carr, Worthen and Pike,[1] of examining a considerable number of specimens of these curious fossils — all from the ironstone nodules of Mazon Creek, Illinois — I bring here the results of my study, which show that these spined myriapods, while allied to the Diplopoda rather than to the Chilopoda, certainly form a very distinct type, which was no doubt the precursor of the Diplopoda; and it appears very probable that even those paleozoic species which have been supposed to resemble closely the modern Iulidae were also spined, and may therefore be presumed to have resembled their evidently spined relations in other points of structure in which the latter are distinguished from modern forms. The reasons for this belief will be given further on.

One main distinction between the two groups, Diplopoda and Chilopoda, into which modern Myriapoda have been divided, consists in the relation of the ventral to the dorsal plates of the body segments. In the Chilopoda there is a single ventral plate, bearing one pair of legs, to every dorsal plate. In the Diplopoda, on the contrary, there are

[1] A considerable number of specimens, including some new species, having been sent me after the first presentation of this paper to the Society, through the kindness of Messrs. Carr, Pike, Armstrong and Bliss, advantage has been taken of the delay in its publication to introduce into the text descriptions of all such additions. (Jan. 31, 1882).

two such ventral plates, each bearing a pair of legs, to every dorsal plate (with the exception of a few segments at the extremities of the body). The Diplopoda are universally considered the lower of the two in their organization and it is therefore not surprising to find that no Chilopoda have been found in rocks older than the tertiary series, while myriapods with two pairs of legs corresponding to each dorsal plate range back through the entire series of rocks to the coal measures.

This being the case, in any comparison which we may make between the ancient and modern types we may leave the Chilopoda entirely out of account, and confine our attention to the points of distinction between the ancient types and the modern Diplopoda. At first we shall confine ourselves, in speaking of the ancient forms, to the large-spined species alone, many of which attain a gigantic size. The head and its appendages, wherein are found the greatest divergencies of structure in the different modern forms, are again so poorly preserved in the carboniferous species that our comparisons must be drawn almost entirely from the structure of the body segments, which are mainly a repetition one of another throughout the body.

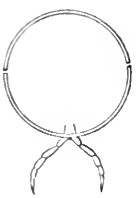


Fig. 1. Cross section of a modern Diplopod. The lines inside the ring mark the separation of the dorsal and ventral plates.

Fig. 2. Side view of a segment of a modern Diplopod.

In modern Diplopoda, each of the segments of the body is composed in large part, almost entirely, of a dorsal plate forming a nearly complete ring, for it encircles nine-tenths of the body as a general rule, leaving scanty room for the pair of ventral plates (see Fig. 1). On the side of the body (Fig. 2) it is perforated by a minute foramen, the opening of an odoriferous gland; usually the ring is nearly circular, but occasionally the body is considerably flattened and the sides are sometimes expanded into flattened laminae, with a smooth or serrate margin; a few species are provided with minute hairs, sometimes perched on little papillae; and the surface of the body, ordinarily smooth or at best wrinkled, is occasionally beset with roughened tubercles which may even form jagged projections. So far as I am aware, no nearer approach to spines occurs on this dorsal plate than the serrate edges of the lateral laminae, the roughened tubercles or the papilla-mounted hairs. In the ancient forms from the coal measures we find a very different condition of things. The body segments may be nearly circular, or they may be laterally compressed, or, as in many modern types, depressed; but in all, the dorsal plate occupies at most apparently only two-thirds of the circuit of the body, being met by broad ventral plates (see Figs. 3, 4). This

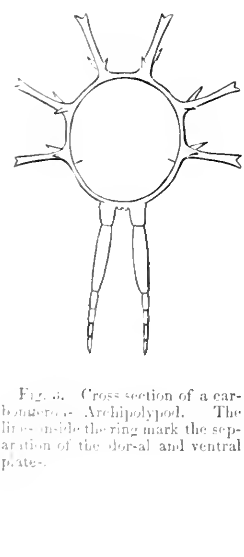


Fig. 3. Cross section of a carboniferous Archipolypod. The lines inside the ring mark the separation of the dorsal and ventral plates.

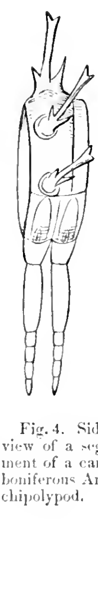


Fig. 4. Side view of a segment of a carboniferous Archipolypod.

dorsal plate is not perforated for foramina repugnatoria,[1] but as means of defence it is armed with huge spines upon either side; one row (for they occur on all the segments) lies above, near the middle line of the body; another lies low down upon the sides near the lower margin of the dorsal plate; and a third row is sometimes interposed between them.[2] These spines are similar in all the rows, but differ in the different species; in few probably are they simple but provided with spinules to a greater or less extent. In the most bristling the spines are forked at the tip, and besides this have a basal corona of stout spinules; others have such a whorl of spinules in the middle of the spine; in nearly all the spines are at least half as long as the width of the body, and sometimes they are nearly as long. These spines are in themselves very remarkable and resemble nothing that I can discover in modern Arthropoda,[3] unless it be certain thorny spines seen in the early stages of some Crustacea, and especially of some found on the tail piece of cirrhiped larvae figured by Claus, to which Mr. Alexander Agassiz has called my attention. Some of his own unpublished drawings of the young of our common barnacle exhibit still closer resemblances, although even here it is not very marked. These spines are fixed, and one can readily picture the difference in external aspect between one of these creatures a foot or more in length, bristling all over with a coarse tangle of spines, and the smooth coiling Iulus of the present day. (See Pl. 10.)

If we pass, however, to the ventral plates we shall find differences of even greater significance. In the modern Diplopoda, as already remarked, these plates are minute; they are similar in size and form; the anterior one forms the anterior edge of the segment, continuous with that of the dorsal plate; together, however, they are not so long as the dorsal plate at their side, and the latter appears partly to encircle the posterior plate by reaching inward towards the coxae of the legs; the legs are attached at the posterior edge, and those of the opposite sides are so closely crowded together that they often absolutely touch each other (Fig. 1); the stigmata, of which there is a pair to each ventral plate, are placed at the outer edge rather toward the front margin; they are minute, and have their openings longitudinal as regards the animal, *i. e.*, they lie athwart the segment; the coxae of the legs of the anterior plate are therefore opposite the stigmata of the posterior plate. No other organs are found upon the ventral plates; one might indeed say there was not room for them. The legs themselves are composed of six cylindrical simple joints, subequal in length, the apical armed with a single terminal claw; the whole leg is short, rarely more than half as long as the diameter of the body.

In the ancient types all is very different. In the first place the ventral plates, which are of equal size, occupy the entire ventral surface, and perhaps may be said to extend partly up the sides of the rounded body, and no part of the dorsal plate passes behind the

[1] This is what would be expected from the presence of spines; two such means of defence should not be looked for in the same animal; offensive glands are present only in slow-moving, or otherwise defenceless creatures, as in Phasmidae among Orthoptera for example.

[2] In one species there is only one row of spines on either side, situated where the third row occurs in the trebly spined forms.

[3] Since this was written, Mr. J. H. Comstock has shown me his capital drawings of Coccidae and pointed out to me forked spines, microscopic indeed, fringing the last abdominal segment of the female, and occurring, he says, only in the sub-family Diaspinae.

The spines of these myriapods have nothing to do with the barbed hairs on the body of the embryonic Strongylosoma as figured by Metschnikoff (Zeitsch. f. wiss. Zool., XXIV, pl. 26, fig. 1 *a*.). These latter are comparable with the dermal appendages of the embryonic larvae of Lepidoptera See my Butterflies, pp. 28-32, figs. 36, 37.

the posterior ventral plate; they are together equal in length to any part of the dorsal plate, the rings of which the body is composed being equal; while in modern Diplopoda the dorsal portion of the dorsal plate is always considerably longer than the ventral portion, allowing the creature to coil ventrally without exposing any intersegmental portion of the back devoid of hard armature; while in these ancient forms, the animal appears to coil dorsally as readily as ventrally; at least, when not extended straight upon the stones in which they are preserved, they are as frequently found bent upward as downward — or perhaps more frequently; and there is nothing certainly in their structure to prevent it. Indeed in one species, *E. flabellata*, the ventral plates seem to be divided on either side in the middle, apparently allowing of even greater flexibility, which the arrangement of the posterior dorsal plates for a terminal flap, apparently for aquatic propulsion, would perhaps require in an unusual degree. Then the legs, instead of being inserted at the extreme posterior edge of the plate, originate from almost its very centre, and are indeed so large that they nearly occupy the whole of it, a thin lamina only being left at the posterior edge of the coxal cavities, though a wider space remains in front; neither are they inserted close together, but are removed from one another by a space equal to their own width, so that they have ample play (Fig. 3). The legs themselves (see Pl. 11, fig. 11) differ from those of modern types in having the second joint as long as the others combined, and the whole leg as long as the diameter of the body, sometimes nearly twice as long; moreover they are not cylindrical but compressed and slightly expanded, strengthened also on the flattened surface by longitudinal ridges, and have in every respect the aspect of *swimming legs* in those specimens in which the appearance of the legs is most clear. No modern aquatic myriapods are known. The spiracles, instead of being minute and having the position seen in modern Diplopoda, are very large, situated in the middle of each ventral plate (Fig. 4), each spiracle opposite to and indeed touching the outside of the coxal cavity of the plate to which it belongs, and running therefore with and not athwart the plate, *i. e.* across the body; its length equals the diameter of the large coxal cavities.

But in addition to these structures, which make up the sum of the furniture of the ventral plates in modern Diplopoda, we find in these ancient types some further interesting organs, which are so perfectly preserved that no doubt can be entertained concerning their presence and their adherence to the ventral plates. The coxal cavities are not circular but oval and are situated with the major axis in an oblique line, running from near the middle line of the body forward and outward; this, and the slight posterior insertion of the legs leave even a wider space between them on the anterior edge of the plates than posteriorly, and this place is occupied by a pair of peculiar organs (see Fig. 3 and Pl. 11, figs. 1-4), situated one on either side of the median line at the very front edge of the ventral plate; to these it seems to be impossible to assign any other function than that of supports for branchiae; they consist of little triangular cups or craters projecting from the under surface, through which I believe the branchial appendages protruded; so far as I am aware, no other organs than branchiae have been found in any Arthropoda situated within the legs, and repeated on segment after segment; a single exception may perhaps be made of Peripatus, in which Balfour has found segmental organs having their external openings somewhat similarly situated; but this being the only known instance of their presence in arthropods[1]; branchiae also occurring in not a few instances nearer the medioventral line of the body than the legs, and branchiae and spiracles coexisting even in the true insects, and then in somewhat similar relative positions (though the branchiae in these instances have never been found next the medioventral line); and the presence further of swimming legs leading us to presume in these creatures an aquatic or amphibious mode of life: I believe we may fairly conceive these cup-shaped organs to be branchial supports, and that we are dealing here with a type of myriapods very different from any existing forms,—suited to an amphibious life, capable of moving and of breathing both on land and in water. Moreover the assemblage of forms discovered in these Mazon Creek beds lends force to this proposition; for the prevalence of aquatic crustacea, of fishes and ferns indicates, what the presence of marsh-frequenting flying insects does not contradict, that the fauna and flora was that of a region abounding in low and boggy land and pools.

These however are not the only points in which the ancient forms differed from the recent. The modern forms are of uniform size throughout, while the ancient, at least when seen from above, tapered noticeably toward either end and especially toward the tail, the largest part of the body being in the neighborhood of the seventh to the tenth body segments, which were often two or even three times broader than the hinder extremity, and considerably broader than the head or the first segment behind it. A single segment seems to have carried all the appendages related to the mouth parts, while in modern types two segments are required for this purpose. This is inferred solely but sufficiently from the fact, even more remarkable, that every segment of the body (as represented by the dorsal plates), even those immediately following the head, is furnished with two ventral plates and bears two pairs of legs. As is well known, the segments immediately following the head-segments in modern Diplopoda have each only one ventral plate and bear only a single pair of legs, — a fact correllated with the embryonic growth of these creatures, since these legs and these only are developed at about the time of hatching. The mature forms of recent Diplopoda therefore here resemble their own young more than do these carboniferous myriapods, a fact which is certainly at variance with the general accord between ancient types and the embryonic condition of their modern representatives, and one for which I can offer no explanatory suggestion worth consideration.

These remarkable points, in which the structure of the carboniferous myriapods are found to be distinguished from modern Diplopoda, none of which (with the single exception of the least important, structurally considered, viz. the spined appendages) have before been pointed out, seem to warrant our placing them in a group apart from either of the modern suborders of myriapods, and of a taxonomic value equivalent to them. For this group, the name Archipolypoda is proposed.

Unfortunately the preservation of the appendages of the head in these ancient types has not proved sufficiently good to allow much comparison between them and modern types. This is the more to be regretted since these parts are those on which we depend largely for our judgment of the relationship of the Myriapoda to other Insecta and to Crustacea. If they were present and clearly defined we may well suppose that they would afford some clew to the genetic connection of these great groups.

[1] Attention should be drawn in this place to Ryder's recent observations on the anatomy of Scolopendrella, and especially of its tracheal system (Amer. Nat., xiv, 375), the external openings of which are "inside the bases of the legs."

There are certain features, however, common to most, at least, of these ancient types, which should be mentioned; these are the great breadth and depth of the head, which is the more remarkable from the tapering of the anterior extremity. In one or two specimens also the antennae have been more or less completely preserved (see Pl. 13, figs. 7, 13, 18), and appear to differ little from their modern representatives unless it be in their greater slenderness and brevity, possibly resembling more the embryonic condition of modern types. What appear to be eyes are also preserved in one or two instances (Pl. 11, fig. 10, and Pl. 13, fig. 18), and also present no contrasts worthy of special mention.

Besides these, careful examination has shown in specimens of not less than four species of two genera, the presence of a long and straight unjointed appendage, or pair of appendages, upon the under surface of one of the early segments of the body (the fourth, fifth or sixth), which varies in length from one-half the width of the body to more than its width. It is always entirely different from the spines and clearly not one of the ordinary legs. No other external organ is known in this part of the body in modern Myriapoda, excepting the pair of intromittent organs, which are morphologically legs, supplanting them on the sixth segment, and it seems, therefore, highly probable that we have in these ancient types a movable organ of the same nature, but of an exceedingly simple character. Full description of each instance is given in the text.

The results reached by a study of these spined myriapods of the Mazon Creek nodules lead naturally to the enquiry what their relations were to other paleozoic myriapods. In some of these previously studied [1] I have pointed out what I then believed to be foramina repugnatoria. These are described in *Xylobius sigillariae* Daws., where one specimen is said to have "a slight circular depression in the centre of one of the frustra . . . about half way up the sides of the segment; it resembles and is found in the place of the lateral pores." Also in *X. fractus* Scudd., where "a slight depression, probably a lateral pore, may be seen in the centre of one of the middle frustra of each segment" (only two segments were preserved in this specimen). And also in *Archiulus xylobioides* Scudd., where they occur "from the seventh segment . . . at least to the seventeenth . . . and are placed in the middle of the sides of the segments; they are oblong oval in shape, with their longer diameters vertical; the mean of their diameters averaged 0.2 mm." in specimens the diameter of whose body is about 4 mm. In a subsequent page of the memoir, mention is made of the "large size" of the lateral pores.

In *Iulus Brassi* described by Dohrn [2] he says he was unable to find any foramina, but states that Kner thought he had recognized stigmata on some segments above the legs; "er glaubt an einigen Ringen oberhalb der Beine den Abdruck von Stigmen zu erkennen; gewisse Punkte," adds Dohrn, "an diesen Stellen kann man gewiss dafür ansehen, wenn schon ihre wirkliche Natur nicht zweifellos festzustellen ist".

Woodward in his description [3] of the British *Xylobius sigillariae* (*X. Woodwardi* Scudd.) says: "each segment of the body, wherever sufficiently well preserved to show it, bears upon its lateral portion a slightly raised whart, indicating the position of the pores, stomata or tracheal openings." These are figured in his plate, in fig. 11a, as nearly one-eighth the diameter of the body.

[1] The Carboniferous Myriapods preserved in the sigillarian stumps of Nova Scotia. Mem. Bost. Soc. Nat. Hist., Vol. II, pt. 2, No. 3 (1873).

[2] Verh. naturh. Ver. Rheinl., [3], v, 535-536, taf. 6.

[3] Trans. Geol. Soc. Glasgow, II, 236, pl. 3 (1867).

The great size of these lateral marks struck me, at the time my paper was written, as inconsistent with their reference to the foramina repugnatoria, but there did not then seem to be anything else to which they could be compared. A re-examination of a few specimens of the sigillarian myriapods in my possession, coupled with the statements of Woodward and Dohrn, lead me now to the conclusion that these marks are the scars or bases of spines, which appear as warts or tubercles in many of the Mazon Creek myriapods, or, in casts or views of the interior surface, as pits of greater or less dimensions. Their position would entirely accord with this. Add to this the fact that all of these Iulid-like carboniferous myriapods had a decidedly fusiform body (some more than others) tapering somewhat toward the head and a great deal toward the tail; and that the legs where preserved are of unusual length—both of these features peculiar to the spined myriapods of the Mazon Creek nodules: and I think we may fairly consider it probable that they too possessed some at least of the other features characteristic of the latter, and should be hypothetically classed, until proof to the contrary is found, among the Archipolypoda.

In this paper however no further attention will be paid to these smaller Iuliditorm types, which were not improbably wholly terrestrial in habit, and may very likely have formed a distinct family of Archipolypoda, to which I have already applied the term Archiulidae, and which, in addition to the characteristics mentioned in the paper upon them, were not improbably distinguished from the Mazon Creek myriapods, to which the family name of Euphoberidae may be given, in the absence of branchiae.

It only remains, before proceeding to the discussion of different forms of Euphoberidae, to point out that we have in these Archipolypoda still another proof of the close alliance of the fauna of Europe and America in paleozoic times. The genera Xylobius, Acantherpestes and Euphoberia, including ten of the twelve species of myriapods found in American carboniferous rocks are all represented in the coal measures of England. I shall be able in future papers, from material already in my hands, to point out among other insects additional evidence of great interest in this direction, and shall hope at no distant day to offer lists of the carboniferous insect faunas of Europe and America in parallel columns, so as to bring clearly to the eye this prominent feature of early insect life.

The number of forms of Archipolypoda represented in the carboniferous rocks has proved unexpectedly great. By the kindness of several friends, mostly residents of Morris, from whence the ironstone nodules, in which most of them were found, come, I have been able to study twenty-six specimens, which with the eight previously known belong to twelve distinct species and four different genera. The genera are distinguished in part by the form of the segments, and in part by their armature; Acantherpestes having three rows, Euphoberia two rows, and Amynilyspes one row of spines on either side of the body, while in Eileticus, spines are absent and their place supplied by a series of warts. Euphoberia is far the most abundant in species, Acantherpestes having only two, and Amynilyspes and Eileticus one each.

Order MYRIAPODA.

Suborder ARCHIPOLYPODA.

Paleozoic myriapods, with a fusiform body, largest near the middle of the anterior half or third, the head appendages borne upon a single segment; each segment behind the head composed of a single dorsal and two ventral plates, the dorsal of nearly uniform length superiorly and inferiorly, occupying most of the sides as well as the top of the body; destitute of foramina repugnatoria, and divided into a ridged anterior and flat posterior portion, the anterior provided with longitudinal rows of spines or tubercles; the ventral plates occupying the entire ventral portion, each bearing a pair of long jointed legs, and furnished outside of them with large spiracles, the mouth transversely disposed.

Family EUPHOBERIDAE.

Archipolypoda armed with very large forked or branching spines, occasionally reduced to tubercles, running in several uniform rows along the back or sides of the body, and attached to the dorsal plates; the legs compressed, the second joint much longer than any of the others and the whole adapted to swimming; those of opposite sides well separated at base, and having between their insertions a pair of branchial appendages.

Genus ACANTHERPESTES (ἄκανθα, ἕρπω.)

Acantherpestes Meek and Worthen, Geol. Surv. Ill., III, p. 559 (hypothetical).

Spines bifurcate at tip and arrayed in subdorsal, pleurodorsal and lateral rows. Segments three or more than three times as broad as long.

The name Acantherpestes was suggested for one of the species which falls within this group by Messrs. Meek and Worthen, in case it did not agree with the genus Euphoberia (to which the species itself was referred with question marks) in having two ventral plates corresponding to each dorsal plate. This it does possess, as indeed the very figure they present shows, two pairs of legs being pictured as corresponding to each dorsal plate. Notwithstanding this, and notwithstanding the impropriety of suggesting hypothetical or conditional names for animals whose affinities are not clearly understood, the name is a good one, and rather than burden our heavily taxed science with synonymy, it is brought into requisition.

Acantherpestes major.

Pl. 10, 11, figs. 1–4, 6–8, 10, 11.

Euphoberia ?? major Meek and Worthen. Amer. Journ. Sc. Arts, [2], XLVI, 25–27; —*Ib.*, Geol. Surv. Ill., III, 558–559, fig. (1868).

The figure was reproduced by Woodward in the Geol. Mag., X, p. 105 (1873), and also in his Monograph of the Merostomata, p. 172, fig. 62 (1872).

The specimens upon which this species was founded were very fragmentary, the one figured consisting of only seven segments with a part of one spine, the spine-bases and several imperfect legs. Two other specimens have been placed in my hand by Mr. J. C. Carr, one of which is very perfect and of enormous size, and which was first shown me by Prof J. W. Pike; the other though only fragmentary is the more interesting because it exhibits the ventral plates more clearly than any other specimen of Archipolypoda yet discovered. A third specimen with its reverse, representing a younger individual, has more recently been placed in my hands by Mr. Pike.

In the specimen figured in the Illinois Report, and which by the kindness of Professor Worthen we are able to reproduce here, we have a lateral view, apparently of the anterior part of the cylindrical body a little curved downward, in which the scars of the lower spines and the mammiform bases of the other series are present, besides one or two of those of the uppermost row upon the further side of the body. The width of the body shows how huge the creature must have been. Judging by comparison with the most complete one I have seen, it must have been three decimeters or just about one foot long; "it probably attained a length of 12 to 15 inches" say the describers. The segments, which are about three times as broad as long, are divided transversely into two parts, the arched anterior portion a little longer than the flat posterior part and bearing the spines. The surface is apparently smooth. The spines are altogether wanting beyond their bases with the exception of a single fragment in the uppermost row; and this is evidently one of the basal spinules and not the spine itself, being comparatively small, simple and conical. The bosses and scars, however, show that there was a subdorsal row of spines tolerably near the mediodorsal line, another at the lower portion of the dorsal plate and a third pleurodorsal row considerably nearer the former than the latter. The legs are mostly broken off near their bases, but two or three are longer, and one is represented in the figure (not mentioned in the text) as complete, being regularly conical, shorter than the body, and divided into five nearly equal joints; I cannot doubt that this and the apparent joints of the other legs are either given quite inaccurately or that at all events the marks do not represent the joints of the legs. The length of the fragment is 62 mm. and its width 21 mm.

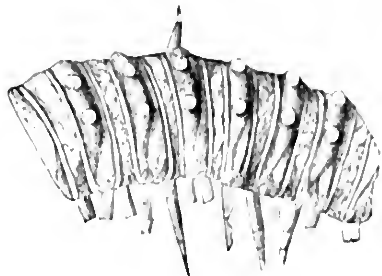


Fig. 5. *Acantherpestes major*

The most complete specimen seen (Pl. 11, figs. 6-8, 11), exhibits a side view of apparently the entire creature, the greater part of the body in a straight line, but the anterior part curved a little upward; along the entire upper line the spines of the subdorsal series may be seen, many of them very perfect; the position of the other rows may be traced by the pits in the body itself, while legs, many of them almost perfect, may be traced along nearly the entire lower margin. The body is cylindrical or nearly cylindrical in form, perhaps a little higher than broad, tapering forward from the seventh or eighth segment so as to be from one fifth to one fourth smaller; and backward from the twelfth or thirteenth segment very uniformly and gradually, so as to be at tip only about one half the greatest breadth. The whole length of the body is 207 mm., its greatest breadth 16 mm. There can hardly be any doubt that the whole animal is preserved. The rapidly tapering form of the extreme hinder extremity with the change in the characteristics of the spines make it certain that the body ended here; at the front extremity the first segment has every appearance of being the termination of the body, and an appendage, presumably an antenna or a part of one, is attached at the upper margin of the front; it would also be in keeping with the general form of these animals as shown by the study of all the species if this anterior segment were the head.

This head segment is only about half the size of one of the nearer body segments, rounded, higher than long, the front rather flattened, and bearing in front, above, a straight antenna composed apparently of three joints, the basal joint equal, small, cylindrical, slender, longer than broad, the apical oblong ovate, twice as broad as the others and four or five times longer than broad; the whole antenna is 6 mm. long, of which two thirds belongs to the apical joint, whose greatest diameter is 0.9 mm. From the lower outer angle of the head projects a bundle of spines (?), which afterwards diverge into three nearly straight rods; they evidently do not belong where they are, but their structure and surface appearance give them the aspect of spines and not of legs; the triangular offshoot from them appears to have no connection with them, but to be an accidental mark in the stone.

The segments of the body behind the head are forty in number, and of a similar size; where the body is broadest the length of the segment is 5.5 mm., and this proportion of length to breadth holds tolerably well throughout, the segments being about three times as broad as long. They appear to be strongly arched and more equally than would appear to be the case in the next specimen to be described, although some segments seem to present an anterior, broad, rounded side where the spines are seated; certainly the segments are deeply and coarsely incised. A large part of the body and of the spines (Pl. 11, fig. 8) are covered with circular flattened raised disks of a yellowish color (Pl. 11, fig. 7), with a slightly raised rim and either a depression or a slight elevation at the centre, crowded closely together and appearing as if formed of the dried up contents of the body; the outside of the spines seem to show them quite as much as the inside of the same; indeed the outside of the spines appears to be entirely made up of them. They are usually about 0.5 mm. in diameter, but a considerable number are smaller and show no structure; the head, antenna and the trifid appendage of the head are all furnished abundantly with them, but they are entirely absent from the legs.

The only spines that are preserved belong, apparently all of them, to the subdorsal row, but the openings into the hollow interiors of those which are necessarily concealed indicate clearly that there are three rows upon either side, arranged exactly as described in the specimen figured by Messrs. Meek and Worthen. The spines of the subdorsal rows (Pl. 11, fig. 8) are cylindrical, equal, hollow throughout, rather longer than the diameter of the body, rather deeply and equally forked at tip, so as to appear Y-shaped, the branches not very divergent; at the base, (in the anterior part of the body), or near the same (in the posterior part of the body), is at least a pair, but more probably a whorl, of subsidiary spines springing from the main stem; anterior and posterior spinules are preserved at the base of nearly all the spines, but there are also indications of others which lie interiorly and exteriorly, and which necessarily cannot be very clearly exhibited in a fossil like this; such an indication appears at the base of Pl. 11, fig. 8, representing the spine enlarged, where a rounded hollow seems to prove a spinule in addition to those in front and behind, as clearly as the other pits in the body walls indicate the position of the principal spines; they appear to originate at the very base of the spine throughout the body and to be less divergent than the other spinules; of the front and hind spinules, the posterior is generally longer and slenderer than the anterior, and situated higher upon the stalk; the double set of holes next the base of the legs in several segments of the body indicates that this was the case also with the lateral spines; these spinules are longer on the posterior part of the body than on the anterior, and have about the same angle from the main stem as the terminal forks from each other. The spines occur, one to a segment in each row, on every segment behind the head; on the penultimate and antepenultimate the main spine seems to end where the spinules spring out, and the latter are of unusual length; on the last segment the same arrangement occurs, though the spinules are very short. The main spines are of uniform size throughout most of their extent, but enlarge slightly above where they fork, and below where the spinules diverge; the spinules are generally tapering and pointed, but in the front part of the body the anterior and posterior ones are stout, often scarcely taper, and are bluntly tipped. The length of the spines is from 12–13 mm., and they are 1.6 mm. in diameter in the middle.

The legs[1] (Pl. 11, fig. 11) are better preserved than in any other of the Archipolypoda examined; the creature is crushed in such a way that one sees in a groove, running beneath the dorsal plates for the greater part of the body, the interior surface of the basal joints of the lower lying legs (the remaining portions of which are buried in the matrix), and just below these upon the plane of the dorsal plates, the exterior surface as well as all the rest of the legs of the upper lying or nearer pairs. They consist of six joints. The first is about twice as long as broad on a side view, narrowing a little at either end; it is about as broad as possible, the series occupying almost the entire space below the segments so as to crowd against each other; it is apparently a little compressed, the outer surface furnished with a distinct longitudinal carina at both anterior and posterior edge and furnished also with a very prominent and stout median longitudinal carina, which is generally a little curved; corresponding to which on the inner face is a rather deep and very abrupt sulcation. The second joint is very different; it is laminate, nearly equal, considerably narrower than the basal joint, very long, being more than six times as long as broad; it has a distinct median carina, at least on the outer side, or perhaps the slightly convex sides are pinched or angulate along the middle; in some instances the one, in others the other appears to be the case, even on adjoining legs. The third joint exactly resembles the second, except in being shorter; it has about the same width, and the same median carina, but it is only about half as long again as broad, equal, quadrate and laminate. The fourth joint is of the same length as the third, but slenderer, a little tapering and with only slight trace of the median carina. The fifth is as long as the fourth, continues the gentle tapering of the leg so as to be nearly half as broad as the second joint, and has no carina. There is pretty certainly another still slenderer and apparently cylindrical joint of about equal length beyond this, but it is only preserved in one or two instances and in part. Nothing positive can be asserted of the claw, but one leg appears to have a single slender gently curving claw of considerable length. The legs are at first sight apparently shorter at the two ends of the body than in the middle, but this is due simply to imperfect preserva-

[1] Between the tips of two of the legs may be seen a crushed molluscan shell, having the appearance of a minute Planorbis, considered by Dr. Dawson (Proc. Bost. Soc. Nat. Hist. XXI, 157) as Spirorbis (Microconchus) carbonarius.

tion, measurements of the second joint showing no difference whatever. The length of the first joint is 2.4 mm.; of the second 7.75 mm.; width of same 1.2 mm.; length of third joint 2.2 mm.; of fourth joint 2.2 mm.; of fifth joint 2.2 mm.; of sixth joint 2.mm.; of the whole leg as it lies on the stone 21 mm. So far as the legs are preserved there are two pairs to every dorsal plate; the stone is broken away next the last two segments so that they do not show there, one only appearing on the penultimate, none on the last segment; the same is true in front, so that none appear on the first segment behind the head, and only one on the second segment; but this one is placed posteriorly, leaving room for an additional one in front of it on the same segment.

Along the ridges which separate the bases of the two sets of legs (of opposite sides) from each other can be seen remnants of the branchial cups to be mentioned further on, but in a fragmentary and often somewhat displaced condition; enough however to show clearly to one who has studied the specimen next to be described that they were present here throughout the greater part of the body, as they can be traced in various parts.

Both relief and intaglio of this specimen are preserved and have helped to reconstruct the myriapod as we have attempted to depict it. They belong to Mr. J. C. Carr of Morris, Illinois, from whom, through the kind intervention of Mr. J. W. Pike, in whose hands I first saw it, it was received for study.

Notwithstanding its far greater incompleteness, the next specimen (Pl. 11, figs. 1-4) of this species to be mentioned rivals the one just described in interest and importance, on account of its perfect exhibition of the ventral plates. It consists of only a few segments from the stouter part of the body, probably presenting an oblique view, mostly dorsal, with a cast of the same. In the breaking of the stone, the part representing the former under crust of the animal has in a small part of the fossil parted from the upper crust, so that in looking upon the dorsal surface one sees also, in the central part of the fossil, the interior view of the ventral plates; and its cast represents, no doubt with tolerable faithfulness, the appearance of the under surface of the ventral plates. The body is a little curved and the posterior segments parted from one another. The convexity of the upper surface of the body well appears, but the form of the body cannot further be told from this specimen. The fragment is 67 mm. long as it lies, but this should be reduced to about 58 mm. to allow for the displacement of the posterior segments. It is 17-18 mm. broad and shows no sign of tapering; probably it is a fragment from the broadest part before the tapering had commenced; on that supposition its size indicates a creature rather larger than the complete specimen last described, but not so large as that described by Meek and Worthen. Eleven segments are present, four anterior ones in their natural relations showing the dorsal plates; then three, also connected with one another and the preceding, but of which the dorsal plates are gone, revealing the inner surface of three pairs of ventral plates; and finally four more dorsal plates separated from one another by more than their own length. The dorsal plates are from 3.75-4.5 mm. long and therefore about four times as broad as long, their anterior half bearing a broadly rounded, elevated, transverse ridge with mammiform knobs which are the broken bases of the spines; the posterior edges of the segments are also a little thickened and slightly elevated, giving the appearance of a slight transverse ridge at this point. The surface appears to be almost or quite smooth; in one or two points a delicate granulation may be seen under a strong lens, and next the hinder edge of some of the segments there appears to be a feeble wrinkling or faint corrugation of the surface. In general only the bases of the spines are present, which so far as can be determined show a disposition very similar to what is seen in the other specimens, but exhibit more clearly than they the relation of the subdorsal series to each other as to distance, showing that they are almost as far removed from each other as they each are from the pleurodorsal series; one or two spines also of this latter series remain and by their structure show that they probably did not differ at all from those of the other series, unless possibly they were slighter and shorter.

The legs do not appear, but on the ventral plates their insertion is plainly visible (Pl. 11, figs. 2-3), showing that the basal joints were probably obliquely appressed, for the coxal cavities are obovate and directed toward the anterior outer edge of the ventral plate next in advance of that on which they are seated; they are also seated a little posteriorly upon the ventral plate, for they reach its posterior edge, but are separated from the anterior border by about one third their own shorter diameter; those of the same ventral plate are also separated from each other by a space equal to at least their own longer diameter.

In the flattened part showing the ventral plates, these extend just as far laterally as the dorsal plates, and the distance from the outer edge, which is preserved upon one side, to their median line is even greater than to the median line of the dorsal plates, showing certainly that they had a wide extent and covered at least the entire under surface of the body; they were of equal size throughout, narrowing only at their extreme lateral extension where they appear to have been rounded. Their length is 2.25 mm. Outside the base of each leg and abutting upon it are the large oblong-ovate spiracles (Pl. 11, figs. 2-3), running transversely to the body, and showing as a deep groove with a very thin laminate ridge along the middle; they are 2.5 mm. long, 0.6 mm. broad. Lying next the front edge of each ventral plate and on either side of the medioventral line of the body, almost attingent at their slightly swollen bases, are the branchial cups (Pl. 11, figs. 2-4), which appear from within as sunken pits, rounded triangular in form, two sides of the triangle being formed by the median line of the body and the front edge of the segment, the latter being the longer; all the angles are well rounded; the floor of this pit is flat, but depressed around the edges, so that the deepest part forms a groove just at the base of the bounding walls; the surface of the floor has in some a spongy aspect with an appearance of converging laminae, but this is not clear; these branchial pits are a third as broad again as long, being 1 mm. in breadth and about 0.75 mm. in length. When viewed from the cast showing these organs as they probably appeared upon the outside of the body (Pl. 11, fig. 4), they appear as crater-like elevations, the rim of which is suboval rather than triangular, with the posterior inner angle of the boundary wall somewhat higher and thicker than the rest; the floor presents nearly the same aspect as in the other face.

This specimen was sent to me by Mr. Pike after I had seen and studied the large and perfect specimen last mentioned. In studying that I had become convinced of the possible aquatic life of the creature from the structure of the long paddling legs, and stated my belief at a meeting of the Boston Society of Natural History held October 20th last. It was therefore with no small pleasure that I subsequently found my conclusions supported in so remarkable a manner by the discovery of these structures on a second individual of the species. Another specimen received from Mr. Carr is as small as that last mentioned and more imperfect, consisting of only a dozen segments or less of the front portion, with scarcely any appendages. It is of particular interest, however, from partially preserving the eye of one side (Pl. 11, fig. 10); it forms an oval boss 3 mm. long and 1.5 mm. broad, gently elevated above the principal curve of the head, situated low down on the anterior portion of the head, its longer diameter vertical; it is covered with nearly hemispherical, low, circular warts about 0.16 mm. in diameter, crowded rather closely but not attingent, and scattered about over the whole convexity with a slight indication of serial arrangement. The length of the fragment is 36 mm. and its breadth about 10 mm.

The last specimen I have to mention was sent to me by Mr. Pike and represents the larger part of a young individual curled in a broad sigmoid curve. Sixteen or seventeen consecutive segments besides the head are preserved, all poorly; the spines and legs are everywhere fragmentary and add nothing to the other specimens; the diameter differs only a very little at different parts, though the usual enlargement of the segments a little way behind the head is indicated. The head itself appears to be larger than the segments behind it, but is very badly preserved. The points of interest in it are: first, that the basal joints of a leg may be seen on the first segment behind the head; second, that the ventral plates, where seen, are divided by a distinct suture into anterior and posterior portions, as does not appear in the other specimens where ventral plates are preserved, but as occurs in some specimens of Euphoberia; and third, that from near the posterior extremity of the sixth (?) segment behind the head, there projects downward a long, straight, stout, cylindrical, bluntly terminated rod, as long as the width of the body, the apical apparently a little stouter than the basal half, suggesting, as in other cases to be mentioned, an intromittent organ. The length of the specimen as it lies is 83 mm.; if straightened it would measure about 97 mm. in length; its diameter is 11 mm.; and the length of the rod mentioned 10 mm.; the greatest diameter of the latter is 1.25 mm.

This species differs from the next to be mentioned in the much less rapidly tapering form of the body, in the proportionally shorter segments, and in the character of the spines, which in this species are longer bodied, rather less divergently and much more equally branched at tip, and are furnished with basal spinules of a remarkable character which are not apparent in the other.

Acantherpestes Brodiei Scudder.

Pl. 11, fig. 5.

"Caterpillar" Westwood in Brodie, Foss. Ins. Eng., xvii, 105, pl. 1, fig. 11 (1845).

Eurypterus? (Euphoberia) ferox (pars) Woodward, Geol. Mag., X, 109–110, fig. 10 (1873).

Arthropleura ferox Woodward, Monogr. Merost., 172, fig. 63 (1872).

Euphoberia ferox Roemer, Leth. geogn., pl. 47, fig. 4 (1874).

Non *Eurypterus ferox* Salter.

This species has been known through Brodie's Fossil Insects for many years, but it is only recently that its relationship was determined. This is partly due to its fragmentary nature, for it is pretty evident from what we now know of the spined myriapods of the carboniferous period that the specimen is considerably imperfect, the head (and perhaps two or three segments more) being absent from the front end and a considerable number of segments at the tail end. It presents a dorsal view of ten segments in the stouter part of the body, enough however to show that it tapered somewhat toward the head and very considerably behind the thickest portion of the body, so that the hinder portion seen is only half as broad as the broadest, only six or seven segments distant; the body has every appearance of having been cylindrical; the fragment is 55 mm. long and 18 mm. broad in the widest part. The segments show a well arched transverse ridge on the anterior portion, which seems generally to occupy much the largest part of the segments, but there is an irregularity about this in the engraving which would seem to be defective; as a whole they are from three to four times as broad as long. The three rows of spines are clearly marked, partly by the spines themselves and partly by the tubercles which mark their former origin; these show the rows to have been equidistant from one another, the subdorsal rows being as far apart as either from the pleurodorsal; the spines are preserved only in the lateral rows; these appear to be uniform, subcylindrical, nearly or quite half as long as the width of the segments (counting to the forks of the spines), expanding at the tip and bearing a couple of stout spinules, the hinder and longer of which is as long as the body of the spine, tapering and pointed, directed slightly backward, and according to Westwood "evidently articulated" at the base; the front and shorter spinule is short, tapering and pointed, directed a little forward. There is no appearance of any basal thorns.

This species may be easily distinguished from *A. major* by its decidedly more tapering body, comparatively shorter and broader segments and the character of the spines, which not only appear to lack the basal thorns, but are very unequally forked at the tip.

The specimen comes from the carboniferous rocks (ironstone?) of Coalbrook Dale in England, and is in the Hope collection at Oxford.

Genus Euphoberia. (εὖ, φοβερός.)

Euphoberia Meek and Worthen, Am. Journ. Sc. Arts, (2), XLVI, 25 (1868). — *Ib.*, Geol. Surv. Ill., III. 556.

Spines spinuliferous, but with a single pointed tip, and arranged in subdorsal and lateral rows only; segments less than three times, generally about twice, as broad as long, rarely less than twice as broad as long, and then only upon a few segments of the body.

Euphoberia ferox.

Pl. 12, fig. 23.

Eurypterus ? (Arthropleura) ferox Salter, Quart. Journ. Geol. Soc. Lond., XIX, 86–87, fig. 8 on p. 84.

Eurypterus ? (Euphoberia) ferox (pars) Woodward, Geol. Mag., X, 109, fig. 8 on p. 105. — *Ib.*, Mongr. Merost., 172, fig. 62 (1872).

Half a dozen segments of the body, seen from above, are all that are preserved of the single known specimen of this animal. The body is equal throughout, but is perhaps broader than high, subcylindrical according to Salter, the surface rugose. Each of the segments is divided into an anterior and posterior portion, the former apparently elevated, spiniferous, occupying from two-thirds to three-fourths of the entire segment, which as a whole is scarcely twice as broad as long. The four rows of spines are represented as if at about equal distances apart, those of the subdorsal row indicated only by their bases; those of the lateral row appear from the figures given to be almost a mere lateral expansion of the edge of the dorsal plate, apparently depressed, forming a laminate compound spine, consisting of a main flange, two-thirds as long as the width of the segment, broad at base and bearing there a triangular, anterior, pointed spinule of considerable size, beyond narrowing and tapering and at the same time curving a little backward to a sharp point, bearing however midway a triangular pointed spinule, very broad at base and nearly as conspicuous as the main spine itself; so that it might be said to be apically forked as in the preceding genus. Salter says that these lateral spines "have at their base, front and back, two other smaller spines," but only an anterior one is figured. "The length of the fragment, including five rings" — the sixth is detached — "is $1\frac{1}{2}$ inch; and the breadth of the axis, without the long forked spines is $\frac{2}{5}$ths inch. The forked spines are $\frac{2}{5}$ths of an inch each."

Locality: North Straffordshire, in ironstone.

This specimen was considered by Salter as "the central lobe of the abdomen of a trilobate Eurypterus or allied genus," and like Westwood in speaking of the last species, he says "it would strike an entomologist as a fossil caterpillar of the Saturnia genus, so strong is its resemblance in size, form and ornament to the larvae of that group." It differs from the other species of Euphoberia in its size, its remarkably depressed spines with very large spinules both at base and in the middle, and appears in these two points to approach Acantherpestes, on which account we have placed it nearest them in this list; its subdorsal spines could hardly have been of the same character as these lateral spines in every respect; and if they did not, this would prove an additional distinction from the other species.

Euphoberia horrida, nov. sp.

Pl. 13, figs. 11, 12, 14.

Messrs. Armstrong and Carr have each sent me a specimen and reverse of an unusually large species of Euphoberia, with highly developed spines, to which the above name may be given. Mr. Carr's specimen (fig. 11), is the better preserved and the more perfect. It apparently represents nearly the entire animal lying partly upon its side, so as to throw the legs upon one side and the subdorsal spines upon the other, but exposing part of the dorsal surface also; toward the hinder extremity the legs appear on both sides; the body lies in a rather strongly sinuous curve, the two extremities broken off, each probably close to the tip, at the edge of the nodule. As it lies it is 107 mm. and if extended would be 119 mm. long, so that its total length must have been at least 130 mm; its width anteriorly is 8 mm.; at the greatest 4.5 mm; at the posterior extremity 10 mm.

About twenty-eight segments are preserved, and there may not have been more than three or four and probably were not over five or six more. The first five or six segments preserved are of equal size, then the body enlarges a little for six or seven more, then diminishes again, and continues to do so with considerable regularity to the hinder extremity, which is hardly more than half as broad as the front extremity, and a little less than half as broad as the middle of the body. The swollen portion of the body is therefore unusually distant from the head. In several places near the middle and at the anterior extremity of the body the original texture of the dorsal plates seems to be preserved (fig. 14), showing that the surface was covered with minute and rather sharply elevated circular papillae, about 0.035 mm. in diameter and pretty uniformly distributed at distances averaging about 0.1 mm. apart; otherwise it appears to be smooth; but the surface of the ventral plates is very finely and transversely striate.

The junction of the dorsal and ventral plates can be seen high up upon the side of the body as it lies, as represented in figure 11, the line of separation being a straight one. The segments, as represented by the dorsal plates, are about twice as broad as long in the middle of the body, which has the appearance of being somewhat contracted and thus shortening the segments, but in front and behind they are proportionally longer, being less than half as broad again as long. The dorsal plates are divided transversely into two equal portions, the front portion being elevated, selliform and spiniferous, the hinder half depressed and nearly flat.

The spines of only one series, apparently the subdorsal, are preserved, but in this throughout nearly the whole length of the body; each is situated on a somewhat elevated boss which merges into the spine, but at base is as broad as the entire front half of the dorsal plate and develops anteriorly the main spine, a stout, cylindrical, erect, straight stem, slightly inclined backward, which in its middle divides into two portions, a comparatively small, short, conical, pointed thorn, continuing very nearly the erect line of the main stem but inclined slightly forward, and a similar but very long and slender pointed thorn, as long as or even longer than the main stem, directed backward at a considerable angle and also slightly curved in the same sense, so as to make the entire spine about half as long as the width of the body in the broadest portion of the same, or about two-thirds its width in the other portions. In addition to this forking of the main stem, the boss expands at its posterior extremity, at the hinder lower elevation of the selliform dorsal plate, and bears the spinules which in other species seem to cluster more strongly to the very base of the main stem of the spine; these spinules are two in number, straight, vertical or inclined backward a little, the anterior much longer than the posterior, both slender, nearly equal, tapering only next the pointed tip, arising from a very short main stem which is even stouter than the main stem of the spine proper, the tip of the longer spinule reaching about as high above the body as the fork of the main spine.

The legs are preserved throughout the greater part of the fragment, but so indistinctly that in no case can the joints be determined with any precision; they appear in general to be divided much as in *Acantherpestes major*, but they are proportionally slenderer than there, as is the case with all other species of Euphoberia; they are slightly shorter than the width of the body excepting near the slender hinder extremity, where they do not diminish in size and length so rapidly as the segments, and are therefore proportionally to the width of the body longer than elsewhere; they appear, as in *Acantherpestes major*, to have a median carina, to taper gradually, especially in the apical third and to be either bluntly pointed at the tip, or, in other places, rounded. The legs are about 7 mm. long in the front part of the body, 9 mm. in the middle and 5.5 mm. at the posterior extremity. The spines are about 5 mm. long.

Mr. Armstrong's specimen represents nearly as large an individual as the preceding, but it is not so well preserved. nor is the fragment so great, being composed of thirteen or fourteen segments besides the head. and exhibiting a dorsal view, but with some of the ventral plates exposed. The fragment is 72 mm. long. stretched in a straight line, 8.5 mm. broad in the broadest part (near the middle of the fragment), from either side of which it diminishes regularly and very slightly so as to be about 6 mm. broad at the segment behind the head. and 7.5 mm. broad at the end of the fragment; it is largest and about equally large from the fourth to the eleventh segment behind the head. The spines, the lateral rows of which are exposed along either side of the body, are exactly similar in structure in every particular to those of the preceding specimen, but are a little longer in proportion to the width of the body than there, being 6 mm. long where the width of the body is a little more than 8 mm. Signs of the position of some of the close y approx - mated subdorsal series may also be seen. Excepting at the hindmost end of the fragment, the segments are everywhere scarcely half as broad. again as their length. No legs are visible, but on one side of the fourth (or fifth ?) segment behind the head is a straight, equal, apically pointed, compressed, unjointed rod, carinate along the middle, as stout as the stem of the spines, nearly three-fourths as long as the width of the segment on which it is seated, and projecting from it at right angles (fig. 12). Probably, as in other cases to be given in other species. it is the intromittent organ; it is 5.75 mm. long and 0.6 mm. broad; as the first segment preserved is not unquestionably the head, the segment on which the rod is situated is of course uncertain; the reasons for supposing it to be the head are that the body appears to terminate there, just before the edge of the stone, and that the segment itself, while bearing no appendages, is, as is the case with the head in specimens of other species of Euphoberia, more deeply impressed and extends further on one side than on the other of the fossil. No characteristics beyond this can be made out.

This species differs from the other of the genus in its greater size, and from the next, to which it is most nearly allied, in its proportionally longer segments and in the more extended development of the basal posterior spinules of the spines of the body, which in this species are more widely separated from the main stem than usual.

Euphoberia armigera Meek and Worthen.

Pl. 12, figs. 1, 2, 3, 5, 6, 13; — pl. 13, figs. 7, 8, 10.

Euphoberia armigera Meek and Worthen, Amer. Journ. Sc. Arts, (2), XLVI, 25-26 (1868); — *Ib.*, Geol. Surv. Ill., III, 556-558 (pars), figs. C, D on p. 556 (1868); — Woodward, Geol. Mag., VIII, 103-104, pl. 3, fig. 7, (1871).

To this species I refer two specimens and reverses received from Mr. Carr, two others with reverses from Mr. Armstrong, another with reverse from Mr. Bliss, another, also with its reverse, from Mr. Worthen. a fragment sent by Mr. Pike, and the two figures C and D of Meek and Worthen's illustration, though it is possible that fig. C may be distinct.

The specimen figured in the Illinois report under the letter D, here reproduced in figure 6, by favor of Mr. Worthen, and which is copied by Woodward as above referred to, exhibits an inferior side view of the entire animal extended in a straight line. From this it seems that the tapering form of the creature does not appear on a side view, and it is even drawn as enlarging toward the head, which is considerably larger than any other part of the animal; toward the hinder extremity, however, it tapers gently; "the entire length is 3.6 inches and its breadth about 0.2 inch." The head is "semicircular, as wide as any part of the long slender body. It is not in a condition to show the eyes, nor are any remains of mandibles, antennae or other appendages preserved." It is represented as less than twice as broad as long. The segments are apparently nearly forty in number besides the head; of the ventral plates "as many as about seventy-five or seventy-six may be counted." The segments themselves are represented as only slightly and uniformly arched on a side view, and appear to be scarcely more than twice as broad as long. According to the authors, the surface of all their specimens, this included, show "a minutely granular appearance;" but they figure only that of one of the others, with which I have a specimen agreeing, which seems to belong certainly to a distinct species, much more granular than those I would refer to this, and I therefore doubt whether the same description should apply to all of Meek and Worthen's specimens. The spines are all represented in dotted lines and it is impossible to say how much of them is intended to represent what can be seen on the specimen. They are represented on every segment behind the head. The legs are also mostly given in dotted lines, there being only one exception, where it is given fully as long as the width of the body and composed of four equal joints; the text, which refers to them all, says "five gradually tapering joints." On the ventral plates little round openings are marked a little above the bases of all the legs, and above them smaller dots; the former, say the authors, may be the point of attachment of the legs; the others they compare to spiracles.

Fig. 6. *Euphoberia armigera*; figure D of Meek and Worthen.

The second specimen figured by Meek and Worthen, marked C on p. 556, and reproduced here in fig. 7, is the posterior portion of a similar animal, presenting the same view as the last mentioned, but bent abruptly downward at the posterior end; it is much more tapering at the hinder end than at the other, being at this part only a little more than half as large as the broken anterior end; although imperfect, it is larger than the other and nearly as long. It has twenty-three segments, which are uniformly arched on a side view, and not more than twice as broad as long. The same statement concerning the surface sculpture may be made of it as of the other specimen. The spines, many of which of the subdorsal (?) series are represented, are rather short and stout, generally less than half as long as the width of the body, but as they appear to originate on its

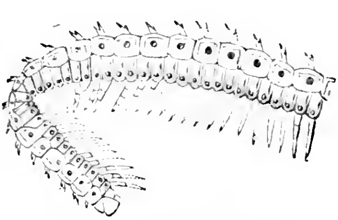


Fig. 7. *Euphoberia armigera*; fig. C of Meek and Worthen.

further side their bases may not show, in which case they are longer; they are tapering and sharply pointed and bear anteriorly, not far before the tip, a small, delicate, pointed spinule; they are represented on every segment but the last. The legs which the text describes (for all the specimens) as five-jointed are three- or four-jointed in all figured, the joints of equal length, the whole leg moderately stout, tapering, and slightly longer than the width of the body. Similar circular holes are shown above the bases of the legs on each of the ventral plates, as in the last specimen mentioned, and like them probably represent the bases of the nearer pair of legs, all of which are wanting.

This specimen differs from the last mentioned in the greater length of the dorsal plates, and in a more conspicuous tapering of the body posteriorly on a similar view; but it probably should be considered as of the same species.

The third specimen which I would refer here is one which I have received from Mr. Carr, and first saw through the kindness of Mr. Pike (Pl. 12, fig. 1). It lies flat upon its back, with the lateral spines projecting equally on either side; a fragment on a higher level at one side shows a few legs, proving that we have here the inner view of the dorsal plates. It is nearly straight and nearly or quite complete. It has the appearance of being unnaturally flattened so as to preserve slight indication of its probably nearly cylindrical form, but its position gives the best view of the form of the animal; it is largest at the end of the first third of the body or from the twelfth to the eighteenth segments; in front of this it tapers very gradually and regularly, so as to be about one fifth smaller just behind the head, while the head itself, as in the first specimen mentioned, is again broader; posteriorly it gradually tapers more until the hinder fourth is reached; this is of nearly uniform width and a little less than one-third smaller than the broadest part; in the form of the front of the body therefore it more nearly resembles the first specimen mentioned (D. fig. 6, supra), while in that of the posterior extremity it is like the second specimen (C. fig. 7, supra); the length of the animal is 105 mm.

As to the head (Pl. 12, fig. 3), it is rounded in front and very short, being much shorter than the body segments and as broad as they, but even broader than those nearest to it; it bears posteriorly a narrow, prominent, transverse ridge which appears to bear on the left side the scar of a subdorsal spine, but situated, like that of the next segment, far toward the side of the body; something which looks like a spine, but which may be an antenna, projects forward and outward from the outer front angle of the head; it is straight, tapering, rather regular and bluntly pointed, as long as the depth of the head; no joints can be seen in it. The segment immediately behind the head is very pinched, not half so long as the head, and bears lateral as well as subdorsal spines; the lateral spine is not represented on the enlarged drawing of this part. The other segments are similar to one another and number thirty-seven, including all but the head; probably they include the whole animal, although the hinder edge of the creature is broken, and there may be one or two more segments; this number it will be noticed agrees very closely with that of the first perfect specimen mentioned. The average length of the body segments is nearly 3 mm. while the average breadth is about 5.5 mm., the segments being about twice as broad as long, in which it agrees again very well with the other specimens described; this proportion holds well throughout the body, the broadest segments measuring about 7 mm. and their length about 3.5 mm.; while at the tail where the width is 4 mm.

the length is barely 2 mm. The segments although much flattened in preservation show, particularly in the larger parts of the body, distinct signs of having been ridged on the anterior half which bears the spines, a feature not seen, where we should the more expect it, in the figures given of the lateral views of the two other specimens.

The head is delicately granulated, the granules oblong with their longer axes longitudinal, and showing a tendency to run together in wavy but generally straight longitudinal ridges; these markings however are rather faint and dull; similar granulation appears obscurely in one or two of the segments behind the head, but shows no tendency to a longitudinal arrangement. The same circular disks which were described in the large specimen of *Acantherpestes major* appear here also all over the body, but the material of which they are formed has generally cracked extensively in an irregular manner, so that they are not so conspicuous; those of average size have a diameter of about 0.35 mm.

The subdorsal row of spines appears only by the little pits upon the surface, which show that these rows are placed a little nearer together than either of them to the lateral rows. The spines (Pl. 12, fig. 2) are preserved in the lateral rows on one side nearly throughout the body, on the other in the anterior third; in their length they show a constant relation to the size of the segments, and are present on all the segments behind the head, excepting near the tail where they are lost. They are more than half as long as the segments on which they occur, very broad at base, rapidly narrowing at first, especially on the hinder edge, and then taper gently, with a slight backward curve, to a delicate pointed tip; they are not compressed or depressed but circular in cross section, and bear at the base posteriorly (only seen in this specimen on one side of the body) a posterior, basal, triangular thorn directed backward and outward; it is stout, conical, pointed and nearly half as long as the segments; its absence from the spines of the right side is due no doubt to the position of these spines, and the spinules might be found attached also to them by cutting the stone; besides this basal posterior thorn, there is an anterior delicate spinule on the middle of the spine plainly visible, at the base of which the spine has a slight bend backward in most cases; this is not shown in the one selected for enlargement (Pl. 12, fig. 2), nor is it brought out in the drawing of the natural size; from certain appearances it looks as if there were, at the point where this anterior spinule arises, not merely this one spinule, but a circlet of them, three or, counting the extremity of the spine as one, four in number; one anterior as described, minute, pointed, hardly directed forward; the posterior or spine proper, which is nearly as long as the basal part of the spine, tapering regularly and pointed, directed only a little backward, divergent from the first at an angle of about 15°, and occasionally very slightly curved backward; still another superior (or interior) one is indicated by a slight mark, seen in the enlarged drawing as a dark spot at the base of the anterior spinule, indicating the base of a spinule; and possibly, to match it, one on the opposite side, of which of course no indication could well appear.

The only appearance of legs is in a short fragment at the middle of one side which slopes down toward the body, where three sets of two each appear; they are of equal length, and therefore are probably complete, for the stone is not split on a different plane from that in which they lie until some distance beyond their extremities; they are therefore very much shorter than in *Acantherpestes major* and considerably shorter than the width of the body; the first joint appears to be broken off at the edge of the stone; the second is equal in length to the remainder of the leg (though this point is obscure and doubtful), slender and compressed, with only a faint sign in one of any carina, equal in width throughout, and about six or seven times as long as broad; the rest of the leg tapers to a bluntly rounded point, with no possibility of making out distinct joints from the obscurity of its preservation; on two, a tapering, curved claw appears to be present, not sharply pointed, less than 0.5 mm. long; the entire leg is 5 mm. long and its greatest breadth 0.4 mm.

The next specimen referred here, and which was received from Mr. Worthen (Pl. 12, fig. 6), presents a nearly straight and uniform ventral view. There is no apparent sign of tapering toward the head, the anterior half being nearly uniform in size; behind this it tapers gradually and uniformly, so that the hinder end is about two-thirds the width of the anterior half. The length of the creature is 98 mm., its greatest breadth 6 mm., narrowing to 4 mm. at the tail. The head and first segment (Pl. 12, fig. 5) are together represented by a deep and large, well rounded depression, in the intaglio half, as broad as the segments behind it, and together much more than equalling two of them; the head would appear to have been much broader than deep and higher than broad, drooping and passing below to a lower plane than the rest of the body, and with the next segment forming a compact globe; next the lower front edge of this globe is a slight rounded depression (indicating a slight boss in the living creature), on which are half a dozen ovate wartlets or granules which may indicate the eye, but it is too vague for any assertion.

The segments are many of them obscure, but appear at first sight very numerous, numbering some sixty or seventy, but as these are the ventral plates the real number is only half of this; the whole body is blurred in parts, rendering it difficult or impossible to be more precise; these ventral plates average 1.5 mm. in length, and where they are distinct, as in the broadest part, they are four times as broad as long; they are well arched transversely, indicating a well rounded body, and have their anterior half stoutly ridged. They show in places series of short, longitudinal, slightly oblique, slight and irregular corrugations. Traces of the insertions of the legs can be seen on many segments, situated in the centre of the front margin of the depressed portions; above them (that is, toward the spined margin) there is a slight trace here and there of stigmata, but I have not been able, so poorly preserved is the fossil, to detect any of the crateriform branchial cups, described in *Acantherpestes major*. The subdorsal spines of a single row are present on many of the segments, but poorly preserved, and are small, being only about one-third the length of the width of the segment on which they occur, rather stout at base, beyond this tapering, and curving slightly backward, and at first sight apparently simple; one, however, faintly shows a part beyond the apparent tip, indicating that the others have been broken; and as this is provided also with a slight anterior spinule in the middle, and a basal posterior thorn, it agrees entirely with the last specimen described. There are a couple of fragments of legs just beneath the junction of the first and second ventral plates behind the head, situated side by side and touching; they apparently represent the basal joints. We have here new proof that the first segment, represented by one dorsal plate behind the head, bore two pair of legs in these myriapods, and the additional evidence derived from the presence of the complete ventral segments to which they were attached. There is besides only a single indication of what may be a leg, which appears at about the eighth ventral plate behind the head, on the side opposite to that to which the spines are attached (Pl. 12, fig. 5); it appears as a straight, cylindrical, slightly tapering, unjointed rod, 4 mm. long, 0.3 mm. broad, the segment from which it springs being 5.3 mm. broad; it has the appearance of a spine, but is altogether unlike any of the other spines and probably represents the intromittent organ.

The next specimen to be discussed is a fragment received from Mr. Pike after this paper was written, and is introduced here with a figure (Pl. 13, fig. 8) of a portion of it, because it exhibits certain features of the ventral portions seen on no other examined. It represents the posterior half, more or less, of a myriapod, extended in a slight sinuous curve, the legs trailing beneath, and a few spines showing above. The length of the fragment is 47 mm., its breadth in front 4 mm., and beyond the middle of its posterior half 1.9 mm.; beyond this it is very obscure, but between these two points it seems to taper regularly. From twenty-one to twenty-three segments are preserved. The jointing of the legs is very obscure but appears to be as in the figure, the basal joint seen, undoubtedly the second, being about as long as the rest of the leg; the legs are about as long as the width of the body, slender and tapering. The subdorsal series of spines, the only ones preserved, are rather small, and show only here and there, and obscurely, any subsidiary spinules. What, however, is of the chief interest is the preservation of the ventral plates in an unusual manner; these are separated from the dorsal plates by a straight line along the middle of the body, and appear to be four in number to each dorsal plate; in reality there are two, each being again divided into a pair of subsegments by a transverse line just behind the middle and only a little more faintly incised than the lines of demarkation between the plates; the appendages are borne only by the anterior, larger, subsegment; these are, so far as can be seen, the legs, which are attached at the extreme base in circular pits; and just above them the spiracles, slender, ovate in form, their longer diameters nearly as great as the diameter of the leg-pit and placed a little obliquely but nearly transverse to the body, the upper end furthest back, thus differing from Acantherpestes only by their slight obliquity. The sight of this specimen inclines me therefore to believe Meek and Worthen to have been correct in referring the openings above the leg attachments (see fig. 6, supra) to spiracles, which they speak of as less rounded than the pits supposed to be the points of attachment of the legs to the body. A similar division of the ventral plates into subequal anterior and posterior portions is evident in other species of Euphoberia, as may be seen from the plates.

Mr. Bliss sends an interesting specimen not very well preserved, indeed, but showing some valuable features of the head (Pl. 13, fig 7). It represents about twenty segments of the body besides the head, lying flat in a straight line, with the lateral rows of spines projecting equally on either side. There are two peculiarities in it which seem to make it a little doubtful whether it should be referred to any of the species of Euphoberia here described: first, the segments are extremely crowded and very short compared to their breadth, varying from two and a half to three times as broad as long; second, the portion of the body exposed, though very favorably displayed for exhibiting any such feature, shows scarcely any enlargement of any region of the body; it does indeed taper slightly from about the eighth segment forward, but so slightly as hardly to be noticed without direct observation; the margins of the body are, however, poorly preserved and may give it a deceptive appearance; it differs slightly also from other specimens of this species in the brevity of the spines, which are less than half as long as the width of the body. From the character of the spines, however, the surface character and general appearance of the segments, and the size of the body, it can hardly be doubted that it belongs to this species. No legs are present, but there are two features worthy of note: first, on one side of the fourth segment behind the head protrudes a pair of straight, attingent, tapering, bluntly-tipped, so far as can be seen unjointed rods, directed at right angles to the body and inclined a little forward, half as long as the width of the fourth segment, and each considerably stouter than the spines; they certainly may be legs though they differ somewhat from them; but appearing at this place only and recalling similar organs in other specimens of Euphoberia one cannot help inclining to believe them to represent intromittent organs, and this speci men has then a special interest from being the only one yet found in which a pair is preserved; second, the appendages of the head; the head is considerably broader than the body, scarcely longer than the body segments, broadly and very regularly rounded in front: from either side of the front, about midway between the middle and the outer margin, springs an antenna, composed of four joints: the first, of which only the apical part can be seen and that obscurely, seems to be small and cylindrical; the second, also obscure, is large, stout, cylindrical, perhaps enlarging apically, a little longer than broad, terminating bluntly: the third about as long as the second but very much slenderer, cylinldrical, enlarging a little apically, terminating bluntly and followed by an ovate termina joint, twice as long as broad and a little narrower than the apex of the penultimate joint.

The length of the fragment is 54 mm.; probably not more than half of the whole is preserved; its greatest breadth is 7.5 mm. and just behind the head 6 mm.; the head is 9.5 mm. broad and 3 mm. long; the whole antenna 3.3 mm. long; second joint 1 mm.; third joint 0.9 mm.; fourth joint 0.45 mm.; greatest width of second joint 0.5 mm.; third joint 0.55 mm.; fourth joint 0.38 mm.

Another specimen and part of its reverse sent by Mr. Carr represent the larger part of a curved body on a lateral view with a few spines and many legs, none of it very well preserved; the head is not reached anteriorly although very few segments behind the head can be missing. Nearly thirty segments are present, representing a large animal, 115 mm. long so far as preserved. The only parts worthy of special mention are the legs, which are in some places very well preserved; they are very nearly as long as the width of the body; the first and second segments are of equal width with parallel sides, but beyond this the leg tapers to a point; the second joint is much longer than the others, longer indeed than the third, fourth and fifth together; the first and third are of equal length and a little longer than the fourth, fifth and sixth, which are of similar length; the first joint is nearly twice as long as broad, the second nearly six times as long as broad, the third twice as long as broad. The legs therefore essentially resemble those of *Acantherpestes major*, differing from them only in detail; the specimen figured (Pl. 13, fig. 10) shows no sign of any median carina, which is visible on some of the legs and not on others. The leg measures 7.25 mm. in total length, the first joint being 1.4 mm. long, the second 2.75 mm., the third 1.3 mm., the fourth and fifth each 0.9 mm.; the last 1 mm.; the width of the second joint is scarcely more than 0.5 mm.

The specimen received from Mr. Armstrong is very imperfect and adds nothing to our knowledge of the species. It is a nearly entire body of a small animal preserved on a side view, with both ends drooping but neither perfect, none of the spines and only a few of the legs partially preserved. The length of the fragment as it lies is 35 mm; if extended it would probably reach 38 mm., and represent the full length, nearly thirty segments being partially or wholly visible.

All the specimens which I refer to this species come from the carboniferous ironstone nodules of Mazon Creek, Morris, Ill. Those which have been personally examined were received from Messrs. Carr, Armstrong, Worthen, Bliss and Pike.

The species differs from the last mentioned in the somewhat shorter segments and less highly developed spines; it is besides somewhat smaller; the spines are longer than in the American species hereinafter mentioned and the shape of the body also differs.

The Scotch *E. Brownii* is not improbably distinct from this, but is said to have no spines preserved, removing one of the best sources of comparison; this, judging from the cast I have, seems to be a mistake, the appendages on the concave side of the body having the appearance of being spines, while those of the convex side are certainly legs. If those of both sides are really legs it presents a dorsal (or a ventral) aspect, and must be considered as distinct from this species because it does not taper to any considerable extent. If it presents, as is far more probable, a side view, like those of the specimens of the present species figured by Meek and Worthen, the spines must be incorrectly drawn in Woodward's figure; on the cast they appear much stouter than the legs (of the convex side), and appear to be of about the same size as in the present species, but with no basal thorn, or none of any size.

Euphoberia Brownii Woodward.

Pl. 12, figs. 7, 8, 21.

Euphoberia Brownii Woodward, Geol. Mag., VIII, 102-104, pl. 3, figs. 6 *a-e*. (1871).

The single specimen upon which this species was based, gives, according to Woodward a dorsal view of the animal in a slightly curved position; but judging from a cast which I owe to his kindness, as well as from the features of the animal as figured by him, we must adopt the view that it presents a lateral aspect. Below, *i. e.* on the convex side, the appendages (legs) are really much longer than those (spines) upon the opposite side, though similarly figured by him, even in an enlarged view (pl. 12, fig. 7, 8); and at this same margin, as in figures C and D of Meek and Worthen's *E. armigera*, though not to so great an extent, the pair of ventral plates can be seen against the lower edges of the dorsal plates; and on the posteror part of the body, from which Woodward's figure 6 (pl. 12, fig. 7) is probably taken, only the lateral row of spine-bases can be seen. The body is flattened and of very nearly uniform size throughout, a little the largest near the seventh segment and a little tapering posteriorly; this form would also indicate a lateral view. The body is 90 mm. long and 6.5 mm. broad at greatest. The head is rather broader than the segments behind it, scarcely more than half as long as they, and well rounded, with a constriction in the middle, giving it the appearance of being formed of two rounded lobes. No appendages can be seen. The segments are stated by Woodward to be thirty-six in number besides the head. They are composed of two equal parts, the anterior forming an arched transverse ridge, undoubtedly that bearing the spines, the posterior flat; as a whole, the segments are about twice as long as broad; nothing is said by Woodward about the surface sculpture. Of the spines Woodward says "there are indications of pores and also of tubercles or spines along the dorsal line, but the latter less perfectly preserved." His enlarged drawing (Pl. 12, fig. 7), shows a single row of marks of spine insertions (?) along the middle line of the body, on the *depressed* portion. To judge from the cast, they seem to be arranged in distant subdorsal and lateral rows, and those of the subdorsal row, as seen beyond the body, to be mammiform at base, beyond tapering, curved, pointed, and as long as the segments, apparently simple, and originating from the *arched* part of the segments; the pits figured by Woodward should probably originate from the other half of the segments and represent the lateral rows. The legs (Pl. 12, fig. 8) are represented as being as long as the width of the body and as composed of three joints, the first and last of equal length and the second as long as the others together; this can hardly be correct.

The only American species with which this can be compared is the one to which Meek and Worthen's name of *E. armigera* is here retained. I have given under that species the reasons for believing that it is distinct, but this cannot be considered as conclusive until a further study of the Scotch specimen is undertaken.

The specimen was found in a nodule of clay ironstone from Kilimaurs, Scotland, by Mr. Thomas Brown.

Euphoberia granosa, nov. sp.

Pl. 12, figs. 22, 24, 25, 26; pl. 13, fig. 13.

Euphoberia armigera Meek and Worthen, Amer. Journ. Sc. Arts, [2], XLVI, p. 25-26 (pars) (1868).—*Ib.*, Geol. Surv. Ill., III, 556-558 (pars), figs. A. B. on p. 556 (1868).—Roemer Leth. geogn., pl. 47, fig. 19 (1876).

The study of the series of specimens that have been intrusted to me, and of the figures and descriptions given by Meek and Worthen, lead me to separate one (A) of those figured by them as distinct from the others, and to place with it some others, for the opportunity of examining which I am indebted to Messrs. Worthen, Carr and Armstrong.

The specimen figured in the Illinois report, and which is reproduced in the accompanying wood cut kindly furnished by Mr. Worthen, presents a dorsal view, with a trace also of the ventral plates of one side of the body in a curved position, neither end preserved, and showing spines upon one side and legs on the other. The body is of nearly uniform size throughout, but tapers a very little posteriorly. It is not so large as any of the previously mentioned species, the fragment being about 54 mm. long, and averaging about 5 mm. broad. The segments preserved are twenty-three in number, each nearly three times as broad as long, the anterior portion transversely ridged and bearing the spines of both rows, and the narrower posterior portion depressed.

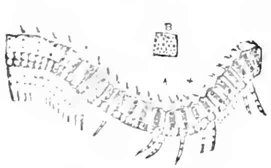


Fig. 8. *Euphoberia granosa.*

The description of the surface sculpture given by Messrs. Meek and Worthen for their species *E. armigera* seems to me to apply only to this specimen, which they have chosen to represent it (in fig. B); they say "Under a magnifier, the surface . . . shows a minutely granular appearance . . . ; as these granules are seen on the surface of moulds or impressions left in the matrix, they indicate the presence of a minutely pitted marking on the fossil itself." The subdorsal series of spines, as indicated by the pits on the surface of the body are distant from each other, and probably quite as near the lateral rows as they are to each other; the spines of the subdorsal rows, which only are preserved in their entirety, are less than half as long as the breadth of the body, stout, conical, curving backward, finely pointed, and bear near the middle a delicate anterior spinule. The legs are represented as tolerably stout, a little longer than the width of the segments and composed of five equal joints.

The first of the specimens I have seen which I refer to this species, and in which we have both obverse and reverse (Pl. 12, figs. 22, 25, 26), was received from Mr. Worthen, and shows a partly dorsal partly lateral view of most of the body, the head end missing, curving upward near the middle so as to be bent nearly at right angles. The anterior half of the fragment is uniform in width; behind, it tapers slightly and regularly, so that the posterior end is about two thirds as broad as the stoutest portion. The entire length of the fragment is 60 mm. and its greatest width 4.25 mm. There are twenty-seven segments preserved, varying from 2 mm. to 2.5 mm. in length, *i.e.* they are about twice as broad as long, or somewhat broader than that; transversely they are not very strongly arched, indicating a somewhat flattened body; longitudinally they are very strongly divided into two parts, the anterior two-thirds being very much elevated, ridged and spiniferous, the posterior third deeply sunken; between the subdorsal spines is a slight, dull, transverse furrow. Over all the segments may be noticed distinct, close granulations, a little coarser on the lower non-spiniferous parts of the segments, and more apparent in the front than in the hinder portions of the body; they appear in the cast of the upper surface and therefore indicate, as Meek and Worthen say, a pitting of the exterior crust (Pl. 12, fig. 24).

The spines of the lateral rows are far down the sides of the body, while the subdorsal rows approach them, being set very widely apart; those only of the lateral rows are preserved (Pl. 12, fig. 24), and are rather more than half as long as the width of the body, tolerably stout, tapering, curved slightly backward, and not very sharply pointed; they have a slight anterior spinule springing from the extreme base. The legs are present along the whole under surface, which is so preserved as to show well the basal joints; these are not so stout, comparatively speaking, as in *Acantherpestes major*, and taper a little, the adjoining legs not touching each other at base but separated by a considerable space; the basal joint is evidently compressed, subquadrate, with a not very pronounced median carina, terminating squarely, a little longer than the basal breadth, and about 1.1 mm. long; the second joint is long and slender, nearly as broad as the tip of the first and about six times as long as broad; it is laminate, straight and equal, with a median carina of no very great prominence; its length is about 2 mm. and its breadth 0.32 mm; a third joint is sometimes visible and is slightly narrower, and only a little longer than broad, quadrate, appearing as a mere continuation of the second; all the parts beyond are broken off in all the legs, the longest of which is 4 mm. where the body is of the same width.

A second specimen belonging to the collection of Mr. Carr (Pl. 13, fig. 13) exhibits on one stone the entire length of the animal, and on the counterpart almost the whole. It lies in a nearly straight line upon its side, showing the spines on one side and the legs on the other, somewhat faintly and imperfectly, but throughout nearly the entire extent of the body. There are nearly forty segments besides the head, but the exact number cannot be determined from the obscurity of some parts. The length as preserved is 63.5 mm. which, if extended, would be about 70 mm.; it is of a nearly uniform width of 3.1 mm. throughout, but tapers posteriorly especially on the apical fourth, so that the hinder extremity is only 2 mm. broad: at its broadest part it measures 3.3 mm.; perhaps by its mode of preservation it does not show the entire breadth, for the legs, which in other specimens of the species are no longer than the body, are here 3.75 mm. long. The spines agree in character with those of the last specimen mentioned, but in only one or two places can the anterior spinule be recognized. The segments of the body are very badly preserved and are hardly twice as broad as long: the structure of the surface can nowhere be distinguished, but some signs exist of the marked distinction between the anterior and posterior portions of the segments; the head again is badly preserved; it is very full in front, and bears a distinct, long and slender antenna, as long as the depth of the head, originating, on a side view, above the middle of the head, and consisting of seven subequal joints; the first and second are slightly longer than broad, rounded subquadrate, a little larger at the tip than at base: the fifth and sixth similar but smaller, the last similar but much smaller, and the third and fourth like the basal ones, but longer and more cylindrical, perhaps a little more than half as long again, or twice as long as broad. The whole antenna is 3 mm. long and in the middle 0.3 mm. broad.

Three specimens of this species, two of them with counterparts, are found in Mr. Armstrong's collection; one of them with its counterpart shows twenty-three segments of the posterior portion of the body lying in a nearly straight line, partly on its side, with spines on one side and legs on the other. The total length is 60 mm. and the broadest part 4.5 mm. wide, a width which is retained with slight diminution until the last 20 or 25 mm. are reached, when the body tapers more rapidly, and just before the tip is reduced to 3.25 mm. As in the last specimen, the anterior basal spinule of the spines is rarely visible, and the spines themselves are unusually slender and pointed, and rather more than half as long as the width of the body. The legs are slightly shorter than the width of the body, and the segments, which are much flattened, and poorly preserved, show signs of the granulation of the surface and the difference of level of the anterior and posterior portions which is characteristic of the species.

The other two specimens referred to this species are very imperfect and add nothing to the points already brought forward.

This species differs from all the others in the coarser pitting of the surface and in the deep and sudden contrast in elevation between subsegments. The segments are also much longer than those of the preceding species, the legs longer than usual and the spines rather shorter, although of the same simple character. The subdorsal spines are separated at an unusual distance, and there is a transverse sulcation between them, in which points it differs markedly from those of all the other species; it seems apparent, therefore, that it cannot be confounded with the other specimens referred by Meek and Worthen to their original *E. armigera*. This species also shows scarcely any sign of tapering, excepting toward the hinder extremity and here very gradually; in this respect it presents features very different from the following species. All the specimens known came from Mazon Creek.

Euphoberia Carri, nov. sp.

Pl. 12, figs. 4, 9-12, 14-19; pl. 13, figs. 16-18.

Five specimens, all showing relief and intaglio, are preserved. The first (Pl. 12, fig. 16), is bent into the shape of an L and presents on the longer anterior limb a dorsal view, but the hinder portion is somewhat twisted as well as bent so as to be partly lateral; both extremities are broken off. The body thus preserved is largest anteriorly, nearly equal on the front half of the fragment; behind this it tapers at first considerably, afterward less rapidly, so that the posterior extremity is scarcely more than half as broad as the anterior portion; the body is very strongly flattened, but may have been rounded. The fragment is about 58 mm. long, 6.5 mm. broad in front and 3.5 mm broad behind. There are twenty-four or twenty-five segments, about twice as broad as long; there is little sign of any ridging in the anterior part of the body, but toward the posterior part the spiniferous portion is clearly seen to be elevated above the plane of the remainder of the segment. The whole body is minutely and closely granulated like a very fine shagreen (Pl. 12, fig. 4, showing the first segment enlarged); there are also some slight signs of the same circular disks that have been described in other specimens, and which are of the same size as in *Acantherpestes major*.

The subdorsal spines are placed in contiguous rows, which are separated by a considerable space from the lateral row, where only are any preserved entire, and that only in a few places. They are of more uniform length than the width of the body (Pl. 12, figs. 17, 19), being about half as long as the width of the body where the latter is slender, and less than one-third as long in the anterior broader part; they are almost simple, being conical and sharply pointed beyond a more or less mammiform base, curving slightly backward, especially beyond a minute anterior thorn or spinule which springs from the end of the basal third, and is only slightly divergent from the main spine. The legs are preserved at only one part of the fossil, in the slenderer portion of the body; they appear (Pl. 12, fig. 18) to taper throughout and almost uniformly, or a little more rapidly on the apical than the basal half; there is plainly a median carina, and on some it even extends throughout the length of the leg, but it is impossible to tell where the joints are; the whole leg is 4.75 mm. long, where the width of the body is slightly less than that.

The second specimen (Pl. 12, figs. 9, 12) probably presents the animal throughout its entire length, exhibiting a side view of the creature, doubled upon itself downwards in front of the middle, the front portion considerably curved and overlapping the other. The body tapers forward, but not very strongly, from about the seventh segment; the broadest part appears to have continued for about ten or twelve segments (the bend renders this uncertain) and then to have tapered rapidly, for the hinder third is uniform and nearly half as broad only as the broadest part; the body was plainly cylindrical, about 42 mm. long, 4.25 mm. broad at the broadest part and 2.5 mm. in the apical half.

The head (Pl. 12, figs. 14, 15) consists of a single segment considerably appressed, well rounded, not so long as the next segment behind it, but much deeper than it and drooping; what little can be seen of the surface is pitted and rugose; something which looks as if it might be an antenna droops from the upper anterior margin of the head, curved, tapering, and apparently rugose like the head, or else broken up into a great number of joints; the whole is however very problematical. The segments are difficult to determine from the doubled position of the fossil, but there are apparently only twenty-eight of them; in all excepting the broadest part of the body they are twice as broad as long; there, they are a little more than twice as broad as long; the anterior half is transversely ridged and bears the spines, while the posterior half is flattened. The segments in the posterior portion of the body show a very faint, rather coarse and distant, scarcely noticeable granulation, but it is not elsewhere visible.

The subdorsal rows of spines are a little nearer to each other than either of them are to the lateral rows, as indicated by the pits; the only spines that remain are a few of the subdorsal series, near the front and again at the hinder end of the body, all of which are simple, straight, regularly conical, bluntly pointed, and directed backward; they have no subsidiary spinules, and are less than half as long as the width of the segments on which they are seated; a single one of the spines (Pl. 12, fig. 11) appears double and forked; it is probably due to the accidental presence of a broken spine. The spines originate near the front of the anterior ridged part of the segments. A few legs may be seen scattered along one side of the hinder portion of the body; none of them are perfect, and all that can be said of them is that they are slender (Pl. 12, fig. 10), flattened and tapering, with a median carina, at least on the basal portions; they are fully as long as the width of the segments to which they are attached; the longest fragments, apparently showing the tips in natural position, are 2.6 mm. long and 0.25 mm. broad, the segment to which they belong being 2.25 mm. broad. A few legs may be seen depending from the anterior part of the body (Pl. 12, figs. 14,15), and have special interest as certainly appendages of the first and second segments behind the head; one is attached to the hinder part of the first segment, leaving ample room for another in front of it, and there is an obscure appearance of the base of such a leg at its proper place, having the same form and general direction as the hinder one; in addition there is a third leg at the anterior edge of the second segment of exactly similar appearance; these legs are perhaps imperfect, but they are as long as the width of the segments at this point, compressed, tapering, straight and of moderate stoutness, with a slight indication of a median carina; joints cannot be made out; they are 3 mm. long and 0.5 mm. broad at base.

The third specimen (Pl. 13, fig. 16) also represents the entire animal, bent in the middle and showing a partially side view, so that the legs appear on one side and the spines on the other. There are from thirty to forty segments besides the head, the exact number being indeterminable; the larger part of the body includes the first sixteen segments; with the seventeenth the body begins to taper considerably for several segments, and then narrows very gradually to the hinder extremity, which is only a very little more than half as broad as the broadest part; in the broadest part the segments are rather more, in the narrower part somewhat less, than twice as broad as long. The specimen is 48 mm. long, 3.25 mm. broad in front, and 2 mm. broad behind; in some places the surface appears to be closely and rather minutely granulated. The only spines preserved are some of those of the subdorsal row on the wider part of the body, where they are slender, conical, pointed, curved backward, as long as half the width of the body, generally furnished with a minute anterior spinule about the middle of the spine, which is directed upward or scarcely forward; the spinule is not half so long as the thickness of the middle of the spine, and is indeed sometimes wanting. The legs are also preserved in the same part of the body and not elsewhere and are considerably shorter than the width of the body, being only from 2.25 to 2.5 mm. long, where the body is considerably broader. It should also be noted that the segment behind the head bears not only a spine but apparently at least one pair of legs, while on the second and each of the succeeding segments two pairs of legs are preserved.

But the greatest interest in this specimen is found in the head and its appendages. It is very short, with a well rounded front, and extends downward, as in the preceding specimen, considerably beyond the general lower line of the body. At its upper outer limit one sees a rounded oval space covered with a cluster of about a dozen large prominent hemispherical wartlets, each separated from the others by nearly its own diameter, and which together represent, apparently, the eye. It will be noticed that it appears on the upper part of the head and not, as in a specimen of *Acantherpestes major*, on the lower part. Projecting beyond the lower edge of the front is seen a long and slender jointed organ, which seems to be an antenna, agreeing in a general way with that found in *E. granosa*. It is about as long as the legs, nearly equal, perhaps a little larger in the middle than at the two ends, moniliform, composed of five subequal, broad, obpyriform joints, a little longer than broad, besides a much smaller, roundish oval, apical joint. The whole length of the antenna is 2.6 mm. and its middle width 0.3 mm. (Pl. 13, fig. 18.)

This specimen differs from all the others in the greater length and slenderness of the subdorsal spines, but agrees so well in its other characteristics that there are hardly valid grounds for its separation from them.

The fourth specimen is the largest of all though not very perfect; apparently the whole creature from head to tail is represented. It is 75 mm. long and appears to have about 33 or 34 segments besides the head, but some of the posterior segments are very obscure, making the exact number uncertain; the body tapers forward from about the fifth segment, but only slightly; back of this as far as the sixteenth segment or thereabouts, they are of nearly equal size, and then taper again a little more rapidly; but not so much so as usual in this species, although the hinder half of the body as a whole is only just half the breadth of the front part, the breadth in the front portion being 5.8 mm., in the middle of the hinder half 2.9 mm., at the hinder extremity 2.5 mm., and on the first segment behind the head 4.2 mm. The body is preserved on a dorsal view and the segments of the broader portion are a little more than twice as broad as long. The spines are very small, shaped as in the first specimen described, and not more than one-fourth as long as the width of the body in its broadest part. The legs are only to be seen in a few places; on the segments directly behind the head they are about three-fourths as long as the width of the segments, while near the middle and a little behind the middle of the body they are nearly as long as the width of the segment bearing them.

The head is about as long as the segments next it but much broader; indeed nearly twice as broad, being 7.5 mm. broad, with a well rounded front. No traces of any appendages can be seen. The second and third segments behind the head bear each two pair of legs, and the first segment a spine. This and all the specimens hitherto mentioned were received from Mr. Carr.

The last specimen to be mentioned (Pl. 13, fig 17), and which belongs to Mr. Armstrong, is a mere fragment of the head end of the body, showing about seven segments besides the head, upon a side view. The fragment is 16 mm. long, somewhat curved, and shows spines upon one side and some legs upon the other. The spines are small and obscure, 1 mm. long and scarcely more than one-fourth as long as the width of the body. The legs are more distinct and are considerably longer than the width of the anterior segments where only they can be seen: a single unusually stout pair is attached to each of the first two segments behind the head, much stouter than, though of the same length as, the legs behind them, probably from being preserved on a front instead of a lateral view, thus indicating the possible paddle-like condition of legs, which appear to be very slender; whether there are other legs attached to those segments is uncertain; these legs are 3.5 mm. long, as long as the width of the body at this point.

The head is considerably larger than the segments behind it and droops as in the second specimen described, falling considerably below the level of the body. As there, the front is full and well rounded, and terminates below in a beak-like projection, forming a very pointed and slightly recurved lip. From the lower portion of the front, at the base as it were of the lip, projects the single, basal, joint of an antenna, which is somewhat obovate in shape and 0.5 mm. long.

This species is remarkable for the suddenness with which, and extent to which, the body tapers: the hinder half as a whole is only about half as broad as the front half as a whole, and somewhere about the middle of the body nearly the whole alteration in size occurs, falling often upon three or four segments. In the character of its spines, it is closely related to the preceding species, but the subdorsal rows are not nearly so distant from each other. It is also related to the same species in the form of the segments as a whole, but differs in this respect from the two following species, in each of which the segments have a peculiar form, and where also the outline of the entire body is different.

The opportunity of studying this species is due mainly to the favor of Mr. J. C. Carr, of Morris, Ill., for whom the species is named and to whose cabinet four of the five specimens belong. The remaining one belongs to the collection of Mr. P. A. Armstrong. They occur in the ironstone nodules of Mazon Creek.

Euphoberia flabellata, nov. sp.

Pl. 13, fig. 15.

Through the kindness of Mr. Pike I have been able, after the other species had been studied, to examine another and tolerably well preserved specimen of this group of myriapods, which can be referred to none of them. It lies upon its side, coiled into the commencement of a very open spiral, and although preserving none of the spines and only a few of the legs, and these imperfectly, it is interesting from the good preservation of the hinder segments, and the exhibition of the dorsal and ventral plates abutting against each other along a line passing nearly down the middle of the exposed surface.

The entire body is preserved in its continuity and consists apparently of thirty-five segments besides the head. The body tapers forward from the eighth segment or thereabouts, and rather rapidly, so that the anterior extremity, including the head, which does not appear to be larger than the segments next it, is scarcely one-fourth the width of the eighth segment: behind this, however, it apparently tapers scarcely at all, until near the hinder end, when the last six or eight segments, and especially the last four, rapidly narrow; the dorsal plates however do diminish in size from near the middle of the body backward, leading to the presumption, that, if better displayed, the creature would show the usual appearance of a swollen second fourth of the body. The dorsal plates are very much larger in the front than in the hind part of the animal, and are nearly quadrate or even slightly broader than long (as exposed), while in the middle they are of equal length and breadth, and posteriorly are longer than broad. This refers however only to the plates as they are shown above the line which appears to separate, along the side of the body, the dorsal and ventral plates; but in the hinder third of the body, or the last dozen segments one sees far below this line the true rounded lateral edges of the segments; between the two very different margins the ventral plates appear, and continue forward nearly to the head, with occasional indications of the division line between consecutive dorsal plates seen through them, or through which the ventral plates are seen; as in many other fossils, both carboniferous and tertiary, the sutural marks of both an originally underlying and an overlying chitinous mass appear upon the same surface, so as frequently to render it quite uncertain which was originally superincumbent. Judging from these appearances the dorsal plates, perhaps only when flattened, were four or five times broader than long, and in front of the last six segments regularly and fully rounded; in these last six segments, the anterior half is rounded as before, or very nearly so, but the outer hinder angle is produced, bearing a triangular process which extends to the middle of the succeeding segment; together they give a straight margin to the sides of the body at this point, and evidently form by their combination a terminal flap, since the triangular process closes the lateral excavation which the rounded front angle would otherwise create (whence the specific name); a rapid forward and backward movement of this part, after the manner of macruran crustacea, would propel the creature backward in the water; and we have seen that the structure of these myriapods allowed so much freedom of movement between the joints, as to render it no great surprise to find a movement so peculiar for myriapods to-day indicated by the special structure of the segments. It adds too another fact in support of the theory that these were aquatic or partially aquatic animals.

Perhaps a similar flexibility of the body is indicated by a feature seen in the ventral plates, which seems entirely different from anything hitherto found in the Archipolypoda. These plates, as stated, are visible along the inner side of the body throughout a large part of its length, two to each one of the dorsal plates; and along the middle of their course they are broken by a longitudinal suture, (*i. e.* transverse to the segment), which is only not continuous from one plate to the next on account of the lateral sliding, due to the curled position of the animal; where it becomes straight, at the tail, these breaks are also continuous; in one instance, near the middle of the body, the ventral plate is again broken by a second suture next the dorsal plate, but no similar case is noticed elsewhere. Such a fracturing of the ventral plates has nowhere else been seen in these ancient myriapods from Mazon Creek, although in several the parts equivalent to these are amply exposed; but their regularity here is such that it cannot be looked upon as accidental, but only as an inherent structural feature, and reminds one of the repeated and regular fracture of the dorsal plates in Xylobius, where I have shown this peculiarity to be a feature of the entire genus.

Next the outer side of the coiled specimen one sees, partly on one stone, partly on its counterpart, a partial duplicate as it were of the fossil, a feature which I have seen in other fossils, and for which I scarcely understand how to account; it is as if a cast of the creature had been taken, left connected at one edge, then turned over on this edge as by a hinge, without rupture, and laid down beside it; for here, and always, if I rightly recollect, it is concave while the fossil proper is convex. But here at least it does not perfectly repeat the parts which lie beside it, especially in that portion of it which I have had drawn, and which is on the half of the stone on which the fossil lies in relief; for the structure of the surface is quite different, and is uniformly flat (excepting for the general concave curve of the whole) instead of showing the irregularities of the bosses on which the spines rest, noticeable in the fossil itself; this surface is finely and regularly striate in a transverse sense, a feature which no doubt belongs to the surface of the fossil at this point, since it is found elsewhere, but which does not appear here on the specimen proper. This fine transverse striation of the surface is a marked feature of this species, and seems to be confined to the dorsal plates, although in the portion of which we have just spoken it extends over a great breadth, apparently as great as the entire supposed width of the dorsal plates, instead of being limited to the narrow breadth of the portion truly exposed at their side. The fine striation seen over the lower half of the body apically is either adventitious or it belongs to some similar cast as this puzzling duplicate; it lies beneath the body in a different axis, for the lines are oblique to the true plates of the fossil, whether dorsal or ventral, and extend slightly beyond their actual limit.

No spines are preserved, but their position can be determined to be the same as in other species by the bosses which mark the bases of the upper series, and in a few places by the small pits which mark the casts of the underlying spines of the lower series, seen through the segments above. Neither can the legs be made out, but only faint indications of them here and there of no value.

There is however an additional though problematical feature in this fossil, of much interest. Below the sixth segment behind the head, but still at some distance from it and therefore not necessarily connected with it, is the impression of a long and slender, straight, rod-like body, consisting of a close series of delicate transverse impressed lines, cut by a central longitudinal impressed line; it is half as long again as the width of the exposed dorsal plates at this point, and nearly or quite as slender as the legs must be. Taken by itself, it would appear of little importance, detached as it is from the body; but considered, with somewhat similar instances in other species of a long and straight appendage to segments at about this point, it cannot be denied that it may indicate an intromittent male organ at this point.

The length of the body, if uncoiled, would be about 44 mm.; its extreme width 4.5 mm.; its width next the head 1.75 mm.; and its width at the seventh segment from the tail 3.8 mm.; the length of the dorsal plates in the middle of the body is 2.1 mm.; the length of the problematical rod 3.2 mm. The specimen comes from the Mazon Creek nodules, and was sent me for study by Mr. J. W. Pike.

Euphoberia flabellata differs strikingly from the other species described in the form of the terminal segments, as well as in the comparative stoutness of the entire body, and its unusually tapering anterior extremity and small head. The spines being unknown and no clear indications of the legs preserved, these important features necessary to distinguish a creature of this sort are much to be desired, but the further distinction of a transversely striate surface of the body may be mentioned. It would seem in some of its features to have closer resemblances than other Euphoberiae to the genus Amynilyspes.

Euphoberia anguilla, nov. sp.

Pl. 12, fig. 20.

The single specimen upon which this species is founded is very obscure, but differs so much from all the others in the parts that can be made out that it must be referred to a distinct species. It is probably a complete animal preserved so as to show a dorsal aspect, bent laterally but not abruptly behind the middle, and the whole, besides, curved in a sinuous manner. The body is remarkably long and slender, broadest from the seventh to tenth segments, tapering in front somewhat rapidly, so that the head, which is somewhat narrower than the segment behind it, is scarcely more than half as broad as the broadest part of the body; behind the tenth segment it tapers very gradually indeed and with great uniformity over considerably more than half the body, so that the hinder end is only two-fifths the width of the broadest part; this and its serpentine position give it an eel-like appearance; the length of the body is about 50 mm.; its greatest breadth 3 mm.; its breadth at posterior extremity 1.2 mm. The head, as stated, is narrower than the following segment and of the same length, subquadrate in form with a flatly rounded front; no appendages can be made out. The segments of the body are difficult to enumerate, owing to the obscurity of certain parts, and especially at the bend of the body, but there are somewhere between 32 and 36 and probably the number is 34. The body, although almost completely flattened in preservation, does not wholly conceal evidence of a former transverse ridging of the anterior part of each segment, not shown in the figure; probably also the body was cylindrical. The segments themselves vary considerably in their proportions, those at the posterior end being much longer in proportion to their width than in the other parts of the body. The last six or seven segments for instance show a gradation from an almost perfectly square form, in the last segment, to a quadrate segment twice as broad as long; while directly in front of this, and also in the broadest part of the body, they are three times as broad as long.

Marks of the position of some of the subdorsal spines can be made out with difficulty, showing that these were not distant from each other. There is also on one side of the broadest part of the body a faint indication of a simple, straight, short, conical, outward directed, lateral spine, next the anterior margin of two or three successive segments; it is scarcely more than one-fourth as long as the width of the same segments. No legs are visible.

This species is remarkable for its extreme slenderness and the delicate tapering of the body, and the length of the posterior segments. In all these respects it differs strikingly from all the species described.

The specimen is from Mazon Creek and was submitted for study by Mr. J. C. Carr, of Morris, Ill.

Genus Amynilyspes, nov. gen. ([illegible])

Spines so far as known simple, conical and pointed, arranged in dorsolateral rows only; segments nearly four times as broad as long, the dorsal plates terminating below in probably free rounded flaps; the extremities and perhaps the whole of the body more or less onisciform.

This genus, represented by a single species and a fragmentary one at that, is so evidently distinct from Euphoberia, to which it is most nearly allied, that there can hardly be any question of the undesirability of placing it therein even provisionally. Its definite separation will call attention to its distinguishing characteristics and bring to light, much sooner than would otherwise be the case, allied forms in carboniferous beds.

Amynilyspes Wortheni, nov. sp.

Pl. 13, figs. 1–4, 9.

A single specimen and its counterpart represent the anterior extremity of the body with about ten or eleven segments. From these it would appear that the form of the body itself did not taper anteriorly, the first three segments behind the head forming with it the common rounded front of the body, each of the three segments becoming successively narrower and shorter from behind forward, while the head, still narrower but a little longer, completed the housiform hood which all combined to form. The body appears to have been stoutly arched, a little flattened above, the sides and front equally deflected, and by the compression of the ventral rings perhaps reaching or nearly reaching the surface on which the creature crawled. With the exception of such modifications as are required for those in front to form the hood, the segments are all alike, each being nearly four times broader than long, and divided about equally into a longitudinally and strongly arched anterior half, and a gently arched posterior half; both portions help to form the deflected lateral lobes, which are triangular, well rounded, and terminate rather in advance of the middle; at the outer edge of the dorsal field, the anterior lobe bears on each side a spine, straight, erect, simple, scarcely tapering above the basal boss until near the bluntly pointed tip, about half as long as the space between the two spines of the same segment; they are borne by every segment behind the head and are just as long on the narrower first and second segments as elsewhere. The head is a little more than half as broad as the entire body, as seen in the specimen simple, and forms the greater part of the front of the hoof-like anterior extremity of the body; no appendages can be made out.

The length of the fragment is 18 mm.; its width 8.1 mm; length of segments 2.15 mm.; length of lateral deflected lobes 2.5 mm.; length of spines 2.8 mm.; breadth of head 5.4 mm.; length of the deflected head-shield 2.9 mm.; space between spines of same segment 5.6 mm.

The single specimen comes from Mazon Creek and was received for study from Mr. P. A. Armstrong. I have dedicated the species to Professor A. H. Worthen, who was the first, with Mr. Meek, to detect the myriapodan character of these spined articulates in his Illinois Geological Reports and elsewhere.

Genus Eileticus, nov. gen. (εἰλητικός.)

Segments longer than in the other genera, being considerably less than twice as broad as long, very few in number, and furnished in place of spines with a series of tubercles, of which there are more than one in the same row upon a single segment.

Although presenting at first glance a very different appearance from the types already described, there seems to be no reason why it should be separated very widely from them; the spines are merely reduced to tubercles, and this reduction allows their multiplication along any one line, especially when the segments are at the same time longer than common. As in the other types, we find a pair of legs attached to the first segment behind the head and the head composed of only one segment; such agreement in general features will not permit a wide distinction, while the minor differences which do occur are certainly of generic value, especially when several are correlated.

Eileticus anthracinus, nov. sp.

Pl. 13, figs. 5, 6.

This species is founded upon a single individual, exhibiting the lateral and partly dorsal view of the anterior portion of the animal; how much is lost posteriorly cannot be positively stated, but the body is unusually stout and short, is largest from the fourth to the eighth segments, and tapers toward either end, slightly in front, rapidly behind, so as rather to indicate that the creature is nearly all preserved; the body was transversely arched and probably nearly cylindrical. It is 41 mm. long and 7.5 mm. broad in the widest part. The head (Pl. 13, fig. 5) is very obscure, but it can be stated to have been well rounded in front, very shallow and broad; the shortness of the head is the more remarkable from its contrast with the great length of the segments, being not one-third their length; from the upper extremity of the front projects a very obscure appendage, which is nearly as long as the depth of the head, very slender, regularly tapering to a point, nearly straight, slightly curved forward, and projecting upward and a little forward; it has some appearance of being broken into a large number of joints.

The segments behind the head are only eleven in number; longitudinally they are perfectly flat, showing no sort of appearance of an anterior transverse ridge, but they are nevertheless composed of two nearly equal parts, a slightly larger anterior part which appears to have been more chitinous, and a posterior more membranous; these segments in the broadest part of the body are 5.5 mm. long, so that they are only half as broad again as long; their surface is entirely smooth excepting for the low mammiform tubercles which take the place of the spines, and which appear to be arranged in low lateral and subdorsal rows. In the lateral row there are two to each segment in the same row, one in either longitudinal half of the segment, of which that on the anterior half appears so much more prominent that it may be the base only of a real spine; in the subdorsal rows, there are three in a row on each segment and confined to the anterior half of the same; these mammiform elevations are shallow and transversely oval or roundish.

Three or four legs are preserved at the anterior extremity, showing the diplopodous character of the fossil and that the legs were long and slender; they are apparently about 6 mm. long where the body is 7 mm. broad, and they are about 0.5 mm. broad in the middle; they appear to be flattened, but from their fragmentary nature no determination of their jointing can be reached. They are interesting from their attachments, for one of them certainly proceeds from (though it is not in absolute connection with) the anterior part of the second segment behind the head, while one in front of it is similarly related to the posterior portion of the first segment; there is also something that looks like the fragment of a leg in part of the last, and which, if so, must be a second leg to the first segment behind the head.

This specimen comes also from the Mazon Creek nodules and was communicated by Prof. A. H. Worthen, of Springfield, Ill.

It may be well, in closing this paper, to refer to other myriapodal or supposed myriapodal remains from the paleozoic formations. No mention has been made of one, *Palaeojulus dyadicus* Geinitz, from the Saxon Permian, because its myriapodal nature has been denied,[1] and it is now conceded by its author to be a fern, as shown by Sterzel, and in any event is too imperfect to be discussed here. Three species of Iulus have also been named (only) by Frič[2] from the Permian rocks of Bohemia. *Anthracerpes typus* from the Mazon Creek beds described by Meek and Worthen,[3] which these authors were "rather inclined to view as a myriapod" when first described, has been referred to the worms, and was afterward so considered by its describers; it is perhaps very fragmentary and may belong here. Goldenberg describes and figures,[4] under the name of *Athopleurion* [*Arthropleurion ?*] *inermis*, a jointed fossil from the coal measures of Saarbrück, which he considers a crustacean, perhaps allied to Arthropleura, and which may possibly be a myriapod; it is, however, not worth discussion until something more perfect and somewhat resembling it is found. Finally Jordan has described and figured,[5] and Goldenberg[6] also, another jointed creature, also from near Saarbrück, which they consider a crustacean, and to which Jordan has given the name of *Chonionotus lithanthraca*. It is here reproduced in Pl. 11, fig. 9. It bears certain resemblances to these spiny myriapods, and perhaps belongs to Acantherpestes. It is however a mere fragment, consisting of only five segments, including perhaps the head. The segments are about four times as broad as long, uniform in size, uniformly and not greatly arched, with no division into an anterior and posterior subsegment. There is a mediodorsal groove, a row of approximate subdorsal tubercles (broken bases of spines ?) situated centrally on the segments, and a pleurodorsal series of similar but a little smaller tubercles showing only on one side. These extend over the four segments behind the front one; this latter is smooth and well rounded in front, as long as the other segments and may possibly represent the head. The length of the fragment is 14 mm. and its breadth 8 mm. By the presence of two rows of spine-bases (?) on either side above (any lateral series not showing), it must be nearer Acantherpestes than Euphoberia; provided indeed it belongs in this group at all, which the fragmentary nature of the fossil by no means allows us to assert.

[1] Cf. Sterzel, Zeitschr. deutch. geol. Gesellsch., 30: 417–420; Neues Jahrb. Mineral., 1878, 729-731; see also p. 733.

[2] Faun. Gaskohle Bohm., I. 31 (1879).

[3] Geol. Surv. Ill., II, 409, pl. 32, fig. 1.

[4] Fauna saraep. foss., II, 48, pl. 2, fig. 20.

[5] Palaeontogr., IV, 12-13, tab. 2, fig. 3.

[6] Fauna saraep. foss., I, 21, pl. 1, fig. 19.

Explanation of the Plates.

PLATE X.

Acantherpestes major. Attempted restoration of a specimen, [illegible] not room on the plate. The body is made rather too slender and [illegible] imperfectly known, is concealed by a drooping frond of *N[illegible]* [illegible] sented as leaving the water in which it is still swimming by means of its [illegible] trunk of a Lepidodendron (*L. vestitum* Lesq.). Upon the trunk [illegible] Scudd., while a broken stem of a Calamites (*C. Cisti* Brongn.) has [illegible] *Neuropteris Loeschii* Brongn. All the figures are of the natural size, and represent [illegible] nodules of Mazon Creek. The plants however, with the exception of the [illegible] Drawn by J. S. Kingsley.

PLATE XI.

[Figs. 4 and 10 are from the drawings of J. H. Blake; figs. 5 and 9 are copied; the rest [illegible] by J. S. Kingsley. All the original drawings are from specimens in the collection of Mr. Carr.

Fig. 1. *Acantherpestes major* $\frac{1}{1}$. This specimen shows in the middle the [illegible] of the ventral plates, and elsewhere the dorsal plates.

Fig. 2. *The same* $\frac{3}{1}$. The reverse of the central portions of fig. 1, showing [illegible] the appearance of the under surface of the body.

Fig. 3. *The same* $\frac{3}{1}$. The central portion of fig. 1, magnified.

Fig. 4. *The same* $\frac{10}{1}$. A pair of the supposed branchial supports, as they appear in fig. 2, enlarged.

Fig. 5. *Acantherpestes Brodiei* of England $\frac{1}{1}$. Copied from Pl. 1, fig. 11, of Brodie's Fossil insects of the secondary rocks of England.

Fig. 6. *Acantherpestes major* $\frac{1}{1}$. The most perfect large specimen that has been discovered.

Fig. 7. *The same* $\frac{7}{1}$. One of the disk-like bodies which cover the surface of the whole fossil excepting the legs.

Fig. 8. *The same* $\frac{3}{1}$. One of the subdorsal spines of fig. 6, on the hinder part of the body; [illegible] nately does not show the base of the third spinule referred to in the text, the original drawing having been lost.

Fig. 9. *Chonionotus lithanthraca* of Germany $\frac{1}{1}$. Copied from Palaeontographica, Vol. IV, pl. 2, [illegible]

Fig. 10. *Acantherpestes major* $\frac{3}{1}$. The head of a third specimen, to show the eye.

Fig. 11. *The same* $\frac{3}{1}$. Three adjoining legs from the middle of the body of the large specimen [illegible] sented in fig. 6.

PLATE XII.

[Figs. 7, 8, 21 and 23 are copied. The others are from drawings by J. S. Kingsley.

Fig. 1. *Euphoberia armigera* $\frac{1}{1}$. Specimen from Mr. Carr's cabinet.

Fig. 2. *The same* $\frac{3}{1}$. An enlarged spine from the above.

Fig. 3. *The same* $\frac{4}{1}$. An enlarged view of the head of the above.

Fig. 4. *Euphoberia Carri* $\frac{1}{1}$. Part of the anterior segment of the specimen shown in fig. 1[illegible]

Fig. 5. *Euphoberia armigera* $\frac{3}{1}$. Anterior extremity of the specimen shown in the next [illegible]

Fig. 6. *The same*. $\frac{1}{1}$. Specimen from Mr. Worthen's collection.

Fig. 7. *Euphoberia Brownii* of Scotland. Enlarged view of some of the segments. [illegible] Geological Magazine, Vol. VIII, pl. 3, fig, 6 *b*.

Fig. 8. *The same*. One of the legs still further enlarged. Copied from the same [illegible]

Fig. 9. *Euphoberia Carri* $\frac{2}{1}$. The doubled specimen from Mr. Carr's collection.

Fig. 10. *The same* $\frac{5}{1}$. One of the legs, poorly preserved, from the same specimen.

Fig. 11. *The same* $\frac{6}{1}$. The apparently forked spine of the same specimen.

Fig. 12. *The same* $\frac{1}{1}$. The reverse of the same specimen.

Fig. 13. *Euphoberia armigera* $\frac{3}{1}$. Two of the segments of the anterior [illegible] fig. 6, exhibiting the spines.

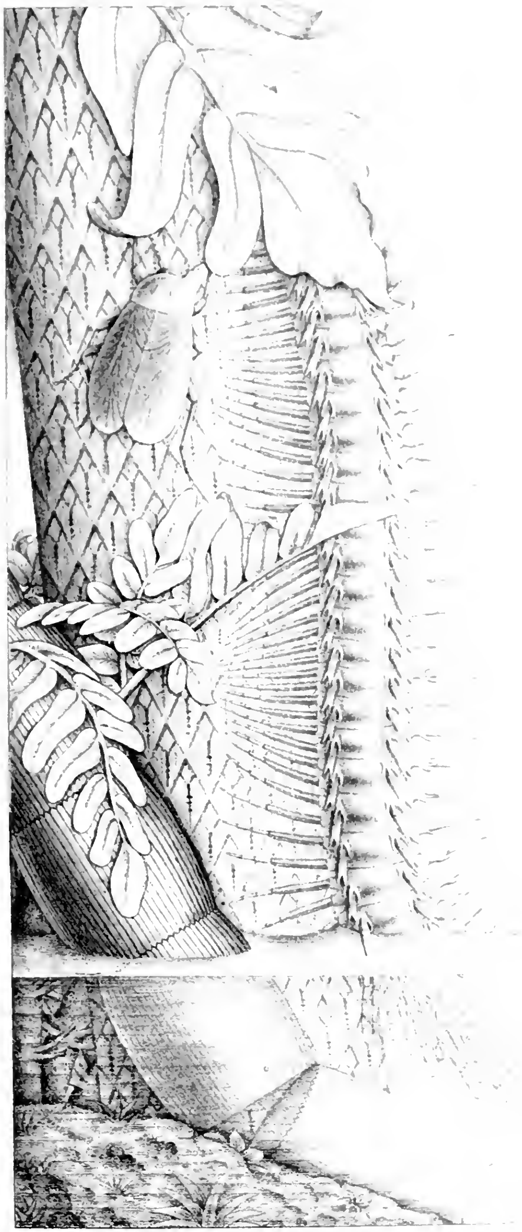
Fig. 14. *Euphoberia Carri* $\frac{4}{1}$. The head of the specimen shown in fig. 12, enlarged.
Fig. 15. *The same* $\frac{4}{1}$. The head of the specimen shown in fig. 9, enlarged.
Fig. 16. *The same* $\frac{1}{1}$. The L-shaped specimen from Mr. Carr's collection.
Fig. 17. *The same* $\frac{4}{1}$. A pair of the spines from the anterior end of the last mentioned specimen.
Fig. 18. *The same* $\frac{4}{1}$. One of the legs on the hinder part of the body of the same.
Fig. 19. *The same* $\frac{2}{1}$. One of the spines on the hinder part of the body of the same.
Fig. 20. *Euphoberia anguilla* $\frac{2}{1}$. From Mr. Carr's collection.
Fig. 21. *Euphoberia Brownii* of Scotland $\frac{1}{1}$. Copied from the Geological Magazine, Vol. VIII, pl. 3, fig. 6 *a*.
Fig. 22. *Euphoberia granosa* $\frac{2}{1}$. The specimen shown in fig. 25, enlarged.
Fig. 23. *Euphoberia ferox* of England $\frac{1}{1}$. Copied from Woodward's figure in the Geological Magazine, Vol. X, p. 105.
Fig. 24. *Euphoberia granosa* $\frac{4}{1}$. The tenth segment of the specimen shown in the next figure, with the spine.
Fig. 25. *The same* $\frac{1}{1}$. From Mr. Worthen's collection.
Fig. 26. *The same* $\frac{2}{1}$. Reverse of the specimen shown in figs. 22 and 25.

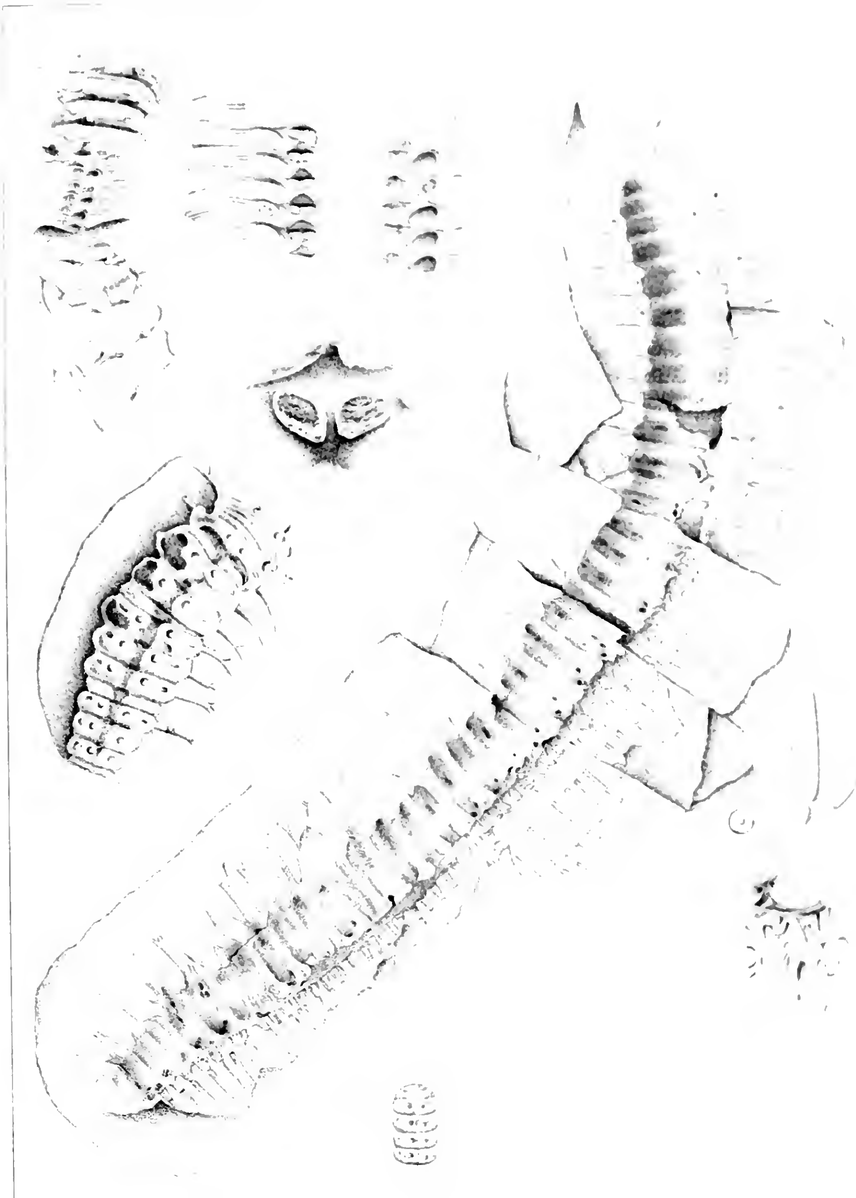
PLATE XIII.

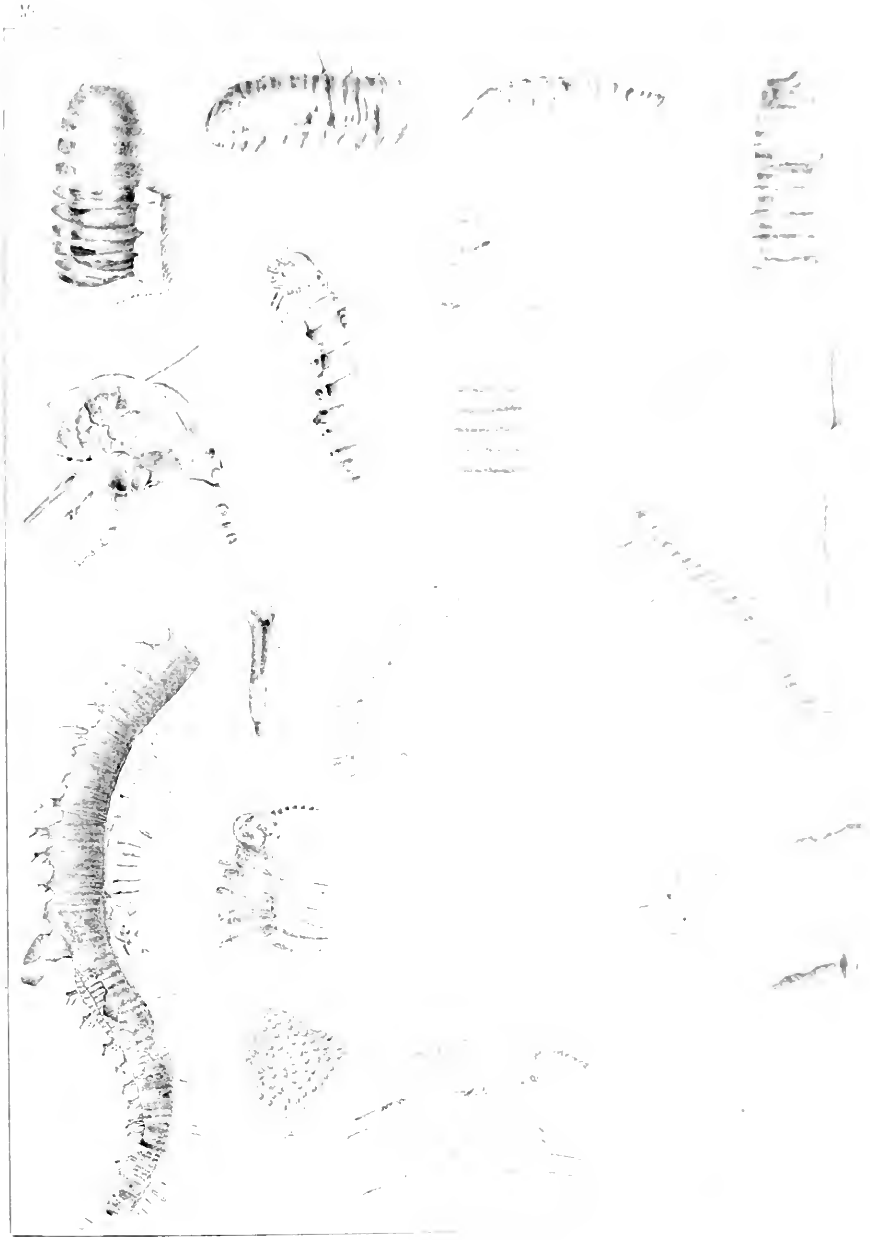
[Figs. 5, 6, 11, 16, were drawn by J. S. Kingsley; the others by J. H. Blake.]

Fig. 1. *Amynilyspes Wortheni* $\frac{2}{1}$. Dorsal view of the fossil in relief. From the collection of Mr. Armstrong.
Fig. 2. *The same* $\frac{2}{1}$. Dorso-lateral view of the same.
Fig. 3. *The same* $\frac{2}{1}$. Lateral view of the same.
Fig. 4. *The same* $\frac{2}{1}$. View of the cast from above.
Fig. 5. *Eileticus anthracinus* $\frac{3}{1}$. The anterior portion of fig. 6, enlarged. The fractures in the third appendage are accidental and do not represent joints.
Fig. 6. *The same* $\frac{1}{1}$. The entire specimen. From the collection of Mr. Worthen.
Fig. 7. *Euphoberia armigera*. The anterior portion $\frac{4}{1}$, showing the head and antennae; and the succeeding segments of the anterior part of the body $\frac{2}{1}$, showing the spines; the hinder segment of the more magnified portion is repeated in the front segment of the less magnified part. From the collection of Mr. Bliss.
Fig. 8. *The same* $\frac{3}{1}$. Three or four segments from the stouter part of the body, showing not only the spines and legs, but also the stigmata. From the collection of Mr. Pike.
Fig. 9. *Amynilyspes Wortheni* $\frac{3}{1}$. The front spine of figs. 1–3.
Fig. 10. *Euphoberia armigera* $\frac{4}{1}$. One of the legs, showing very well the division into joints. From the collection of Mr. Carr.
Fig. 11. *Euphoberia horrida* $\frac{1}{1}$. From Mr. Carr's collection.
Fig. 12. *The same* $\frac{2}{1}$. The supposed intromittent organ. From the collection of Mr. Armstrong.
Fig. 13. *Euphoberia granosa* $\frac{3}{1}$. The anterior portion of the specimen, showing the head and antennae, the legs, and a few spines. From Mr. Carr's collection.
Fig. 14. *Euphoberia horrida* $\frac{20}{1}$. A fragment of fig. 11, from near the middle of the specimen on the right side, to show the character of the surface.
Fig. 15. *Euphoberia flabellata* $\frac{3}{1}$. From Mr. Pike's collection.
Fig. 16. *Euphoberia Carri* $\frac{3}{1}$. From Mr. Carr's collection.
Fig. 17. *The same* $\frac{3}{1}$. The anterior portion of the body, showing the basal joint of the antenna. From Mr. Armstrong's collection.
Fig. 18. *The same* $\frac{6}{1}$. The anterior portion of the reverse of fig. 16, to show better the head, with its eye and antennae, as well as the legs, the comparative breadth of the anterior ones of which is the opposite of what obtains in fig. 16.

NOTE. The introductory part of this paper, nearly as given here, appeared in the American Journal of Science for March, 1881.







VI. Some Observations on the Embryology of the Teleosts.

By J. S. Kingsley and H. W. Conn.

Read March 1[illegible], 1882.[1]

The following observations on the development of a marine bony fish were made at the Summer Laboratory of the Boston Society of Natural History at Annisquam Mass., during the months of June, July and August 1881. Most of the facts here recorded have been witnessed by both authors and in the majority of cases have been repeated many times. The composition of this article is the work of Mr. Kingsley and when the pronoun "we" occurs in the following pages it indicates the fact that both of us are responsible for the statements presented, the phenomena which were witnessed by Mr Conn alone are indicated by the use of his name, while the "I" which will be frequently met in the course of the article indicates that Mr. Kingsley alone is responsible for the statement or interpretation presented. As we separated soon after the conclusion of the observations herein recorded, it has fallen to the lot of Mr. Kingsley to make the comparisons with the work of other authors; and the whole discussion of previous results, with the exception of a portion of the work of Oellacher, has been done by him. The bibliography which follows has been wholly the compilation of Mr. Kingsley and embraces only those papers which have been consulted during the preparation of this article. Nevertheless it is hoped that it may prove of use to other students of Vertebrate Embryology. I have adopted the method of referring to these various papers which is used by Dr. Mark in his valuable memoir on the Maturation, Impregnation and Segmentation of Limax; viz: the name of the author followed by the date of the article in full faced type. Where two or more articles by the same author were published in the same year they have the additional letters [a], [b], [c], etc.

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[1] Owing to the long delay in the publication of this article I have had an opportunity to add extensively to it, having gone over much of the ground again during the summer of 1882. The additions, however, will all appear as foot-notes each with the date 1882. For the opportunities enjoyed for pursuing my investigations I w[illegible] Professor Hyatt and Mr. Van V[illegible] for the [illegible] facilities afforded me during the two seasons [illegible] at Annisquam.

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The eggs on which we worked were obtained by surface skimming and were usually found in about equal abundance at day and in the evening, and as a rule were rather more abundant when the tide was coming in than when it was running out. One or two evenings however proved an exception to the rule, as once with about half an hour's skimming we found over 700 eggs by actual count. This large number however was exceptional, one hundred or one hundred and fifty being near the average.

The most numerous form of egg and the one on which our observations were principally made was perfectly spherical, about a thirtieth of an inch in diameter, and perfectly transparent. The shell enveloping it (*chorion* of older authors) was extremely thin and only under high powers showing a double contour. A Tolles one-tenth objective revealed no traces of any structure in it, nor were there visible any pores such as exist in the egg shells of many Teleosts.[1] The various preparations of carmine and haematoxylin as well as the anilines very quickly stained the shell, but a prolonged immersion in any staining fluid colored the contents of the egg but very imperfectly and very slightly, thus offering a striking contrast with the eggs of Merlucius which were studied at the same time by Mr. Van Vleck, and which stained easily and well. As our eggs were obtained by skimming and were mature and fertilized, there existed between the shell of the egg and the egg proper a narrow space filled with a transparent fluid in which the yolk floats freely. This space is the breathing chamber of Ransom. The food yolk or deutoplasm comprises the greater portion of the egg over one side of which the formative yolk, or protoplasm, is spread as a thin layer. The deutoplasm is perfectly colorless, free from all oil globules or granules of any sort and of nearly the same refractive index as the salt water in which the eggs were kept, rendering it an operation of some difficulty to pick the eggs out of the water in which they were kept, on account of their being nearly invisible. The protoplasm was in the early stages relatively very small, composing less than a twentieth of the bulk of the egg. Like the deutoplasm it was perfectly free from granules or globules of oil or food-yolk but it was of a very pale straw-color and was more refringent than the deutoplasm. With eggs of such transparence one could easily watch most of the changes going on, even in the interior of the egg, while it was on the stage of the microscope, thus affording in this respect a more favorable object than the egg of the trout which has been the subject of so much investigation in Europe.

Upon the above described egg most of the observations were made which form the basis of this paper. When any other form is used the fact will be stated in the text.

We greatly regret that we are unable to identify the eggs on which we worked,[2] but all attempts to rear the young fish beyond a few hours after hatching proved futile. We tried keeping them at the ordinary temperature of the room, keeping them in an ice chest, and in breeding boxes, allowing a free circulation of water, or placed in the water from which the young were taken, but in vain. Mr VanVleck had no better success with the young of Merlucius.

From the numbers of eggs which we found we supposed that they must belong to some abundant shore fish, and the following observations may aid in approximating the species. The flounder (*Platessa americana*) is, according to a letter to Mr. G. Brown Goode, a win-

[1] Conf. His. '73 pl. II. Aubert '54 pl. VI, fig. 1.

[2] During the summer of 1882 I was able to identify the eggs, which turned out to be, as expected, those of the Cunner (*Ctenolabrus coeruleus*).

ter spawning fish. The eggs of the smelt (Osmerus) are over twice the size of those on which we worked. The eggs of Merlucius, Microgadus, Motella, and possibly of all of the Gadidae have one or more conspicuous oil globules in the deutoplasm. The eggs of the Cunner (*Ctenolabrus coeruleus*) taken from the living fish, very closely resemble our specimens in size and appearance, and it seems to us that the probabilities are in favor of our eggs belonging to this species.

On the other hand one would expect to find (if there be any correspondence between closely allied fish and their eggs which, with the possible exception of the Gadidae mentioned above, has not yet been shown[1]) a similarity between our eggs and those of the perch as described and figured by Lereboullet and Ransom. Lereboullet describes the egg of the European perch ('54 p. 241–242) as transparent vesicles containing "globules graiseaux et un grosse goutte huileuse" and also as agglutinated. These features were seen by us neither in the ovarian egg of the Ctenolabrus nor in the ripe, unsegmented egg which we studied. Neither were there present any filiform appendages. Ransom has given a separate description of the egg of the same species, but we saw none of the pores, the rythmic contractions, nor the micropyle[2] which he figures and describes, nor any such tubes as he shows ('67ᵃ Pl. XVI, fig. 26 etc.). The mode of development, especially in the early stages, is also far different from that of the perch as epitomized by Lereboullet.

The other eggs upon which observations were made were:

I. An egg of similar size and appearance with a large reddish colored oil globule in the deutoplasm.

II. An egg of the same size with several reddish oil globules and a slightly granular protoplasm and deutoplasm.

III. A larger egg, about a twentieth of an inch in diameter with one large oil globule.

III. A large egg, about a fifteenth of an inch in diameter (twice that of our form) and like it in being perfectly transparent and in possessing no oil globule, though both its protoplasm and deutoplasm were slightly granular. In all of these eggs the relative amount of food and germinative yolk were about the same.

These eggs all floated at or near the surface of the water and presented a marked contrast to those of an Elasmobranch, Batrachian, Reptile or Bird (and which I have never happened to see mentioned as a characteristic of fish eggs) in that *the germinative portion is invariably downward, or on the lower surface of the egg while the deutoplasm is uppermost.* This peculiarity renders it very easy by inclining the microscope, to rotate the egg into almost any desired position with one exception: it does not permit us to obtain a surface view of the blastoderm. Nor could this be obtained by confining the egg, as the slightest pressure almost immediately killed it, rupturing the vitelline membrane and thus contracting the blastoderm so that nothing could be made out of it. The bad eggs always sank.

[1] [illegible] papers should be consulted in this connection.

[2] During the summer of 1882 I was more fortunate, having [illegible] micropyle. This is shown in Pl. XIV, figs. 1 [illegible] 2. A [illegible] depression surrounds the micropyle which [illegible] in optical section, is a funnel-shaped tube, [illegible] some little distance beyond the rest of [illegible]. Near the micropyle the membrane is [illegible] views is seen to be permeated by very minute tubes (or possibly only surrounded by punctae, though from what is known of other forms, the former view would seem the most probable). I did not see these tubes except very near the micropyle. The micropyle itself more closely approximates that of the Herring as figured by Hoffman ('81, Pl. I, fig. 9) than it does those of the more nearly related Julis and Crenilabrus as figured by the same author on his third plate.

The small size of the eggs and their great contraction in any hardening medium (osmic, chromic, and Kleinenberg's picric acids, bichromate of potash and alcohol) prevented the cutting of any satisfactory sections though many attempts were made. It was also found very difficult to keep the eggs alive for twenty-four hours, and to these two causes must be attributed the fragmentary condition of these notes, of whose shortcomings no one can be more cognizant than the writer. Still in many ways, notably in witnessing the invagination of the hypoblast and the formation of the notochord, the extreme transparence of the eggs rendered our information on these points far more satisfactory than any sections could have done, as every step of the process could be clearly seen.

In the following pages the development of the egg will be taken up by stages, each of which is characterized by some prominent feature or by the appearance of some important organ. From the fact that the several portions of the body are undergoing development at the same time, a perfect chronological arrangement in treating of the subject cannot be maintained, but it is hoped that the general features may be followed in nearly their proper order.

These stages may be briefly indicated and epitomised as follows:

I. The maturation of the ovum. We have been unable to obtain anything on this point in our eggs, but introduce some observations upon the eggs of the "Old England Hake," Merlucius.

II. The phenomena of segmentation until the formation of the germ layers.

III. The formation of the three primary layers, the segmentation cavity, the invagination of the hypoblast, and the appearance of nuclei in the intermediary layer of Van Bambeke.

IV. The formation of the notochord and neural cord. During this stage the invagination is completed.

V. The formation of the optic bulbs and the segmentation of the muscle plates into proto-vertebrae. During this stage the first appearance of what we call "Kupffer's vesicle" and what Balfour regards ('81 p. 61) as the post-anal vesicle, is seen. In the later portion of this stage the splitting of the mesoblast into somatopleure and splanchnopleure begins, while the epiblast in the cephalic region thickens to form the lens of the eye.

VI. In this stage the ears and nasal pits make their appearance and undergo a portion of their development; the lens of the eye is segmented from the epiblast and the first traces of blood vessels were seen; the segmentation of the muscle plates still continues.

VII. The heart and pericardial cavity begin to be differentiated and the former to beat. The blastoderm at this stage completely envelopes the deutoplasm and in subsequent stages will be spoken of as the yolk sac. The gills bud and the gill-arches and gill-arteries appear in the later portion of this stage. In this stage the first contractions and movements of the embryo are seen; simultaneously with the first beating of the heart.

VIII. During this stage the development of the organs previously outlined progresses while the outgrowth of the tail and the formation of the anus are the new features. The fore and hind gut also become prominent and the lumen in the latter is readily seen.

IX. This stage is characterized by the hatching of the embryo and is reached in from forty-eight to fifty-six *hours* after the first segmentation furrows make their appearance, a slight difference in time being noticeable with a change in the temperature. The yolk sac has rapidly decreased in size.

X. The formation of the mouth, the complete disappearance of the yolk sac and the deposition of pigment in the eye.

Though the processes above outlined and now to be described present many striking differences from those which are found in fresh water fishes, they are essentially similar, not only in all the eggs of the marine forms which we have studied, but they also present many resemblances to those of other marine forms as described by Van Beneden, Haeckel, Kupffer and others, though seeming to indicate that there are two distinct types of teleost development, one for the fresh and the other for the salt water forms. However, we are not yet possessed of sufficient material on which to base any generalizations, since we know less about the development of the Teleosts than of any other Vertebrate type with the exception of some of the lower groups of the old class of fishes.

The description which we give is purposely detailed and may be even prolix, and for these reasons: but few forms of marine fishes have been studied and so detailed observations are necessary to serve as a basis for future comparison; the second is that our paper may be of more aid to American students who as a rule have no such facilities for consulting books as have their co-workers in the old world. Besides the works of Alexander Agassiz, Drs. Brooks, Garlick, Lockwood, Putnam, Ryder, and Wyman, referred to in the bibliography, I do not know of a single paper by an American on the embryology of the Teleosts, while all papers embracing any original investigation on the embryology of the other Vertebrates will not exceed two dozen and of these fully one-half were not at their time of publication any contribution to knowledge. With such a poor showing surely anything which may incite to better work may be pardoned.

I. Maturation of the Ovum.

We were unable to make any observations on the maturation of the eggs which we studied,[1] nor to witness the phenomena connected with the impregnation, but the following

[1] During the summer of 1882 eggs were taken from the living cunner some being fertilized and others not, and from the study of the latter I am able to add a little to the account of the maturation of the egg and to say a word concerning the formation of the polar globule in addition to the statements of the previous year. I would, however, state that it is barely possible that the supposed unfertilized eggs were in reality fertilized, as, for obvious reasons, I cannot say that there were no spermatozoa in the water in which they were kept. These eggs in general appearance have been described at the beginning of the second section of this article, and hence the description need not be repeated here. The features of maturation witnessed were a disappearance of the nucleus and of the strongly refractive globules; then the protoplasm began gathering itself together as shown in the figures 9, 10 and 11. A slight constriction appears around the central portion of the protoplasm which, cutting down and then in, separates the germinal portion of the egg from the yolk giving it eventually the shape of a button. It is to be noted that this operation does not include all of the protoplasmic portion of the egg, a thin layer (exaggerated in the figures) extending down over the yolk and in all probibility giving rise to the intermediary layer. While this segregation of the protoplasm is taking place the aster appears, followed by the formation of the polar globule. This aster appeared, each time it was seen, as a true aster, not an amphiaster, but this may be the result of the position of the egg, for were an amphiaster viewed in the direction of the axis it would present this appearance. At the centre of the aster there appeared the polar globule in a manner almost exactly similar to that so often described in the eggs of invertebrates. Once on rotating the egg the polar globule was actually witnessed in its passage through the micropyle as shown in figures 6 and 7, its connection with the egg being completely severed. At another time I saw a projection which I am inclined to regard as a polar globule attached to one of the resulting cells of the first segmentation (fig. 8, *p. g*), but as the process of formation was not witnessed I am not positive

account of the changes undergone by the eggs of Merlucius may partially fill the gap. The eggs in question were taken from the fish and some were fertilized while others were not. We studied only the latter. Mr. Van Vleck spent his time on the development of the former, and it is sincerely to be hoped that he will soon publish his results in detail as many of them are very interesting and important.

When first seen the protoplasm of the egg of Merlucius was collected at one pole (the lower) and covered about a third of the surface of the deutoplasm as a thin layer. At this time no nucleus was visible, though carefully looked for. Soon there appeared, at about the centre of the germinative disc, the well known aster so familiar to embryologists (fig. 3). After about five minutes changes were noticeable in the aster; its rays grew shorter, were less distinctly defined, and finally the whole disappeared and no trace of the star could be seen. The length of time from the first appearance of this aster until its complete disappearance was thirteen minutes. Five minutes later the aster reappeared, this time at the centre of the outer surface of the germinal disc where during an interval of about ten minutes it presented the same appearance and went through the same changes as before, at last disappearing as before leaving no trace of its former presence. After twenty minutes more had elapsed it was again seen near the edge of the disc and on its outer surface, where after remaining in sight for about five minutes it again faded from sight. Several additional appearances and disappearances were witnessed but with no differences worthy of note and no further records were kept. These asters made themselves visible with comparative suddenness, while their disappearance was more gradual and is best described by the term "fading out". Close watch was kept for the formation of polar globules but without success.

The foregoing account is by Mr. Conn, but what interpretation to place upon the numerous appearances and disappearances of the aster I do not know. In another egg of the same lot I saw the following phenomena:

The appearance of only one aster was noticed and this at the outer surface of the germinal disc and close to its outer margin. It was apparently composed of granules of protoplasm radically arranged. At the same time of its appearance slightly marked amoeboid movements of the whole protoplasmic area were seen and which were the most prominent in the neighborhood of the aster and which seemingly proceeded in a slow wave-like manner toward the aster as a centre from the circumference. This appearance was noticed for about five minutes, and as the time progressed the aster gradually faded from the sight as has been described above by Mr. Conn. After its disappearance two very small globules or granules were seen on the surface of the germinal disc in the exact spot formerly occupied by the aster (fig. 2). There exists in my mind considerable doubt as to whether these granules were the polar globules, arising chiefly from the following reasons: their very minute size, and also from the fact that neither by myself nor by Mr. Conn was there witnessed anything comparable to the amphiaster (Archamphiaster of Whitman) which

of my identification. It may be that the exclusion of the polar globule from the egg is the normal method and this would account for the fact that it has so unfrequently been seen in the fishes. With the evidence of the present year I feel tolerably confident that the polar globule of the text (fig. 5 *p. g.*) was in reality such. Hoffman ('81) gives an essentially similar account of the formation of the polar globules and their extension from the egg and, more fortunate than I, saw all the stages of the operation, which were similar to those described by Fol and others in the maturation of the eggs of the Invertebrata. He however does not appear to have seen the polar globules retained within the egg.

accompanies the formation of the polar globule in the Invertebrates. The star was always single, nothing comparable to the "Kern-platte" was seen,[1] and in my egg the elongate globules, arranged in the direction of their longer axes, marked the exact centre of the aster. Though watched for a considerable time no further changes were witnessed, and as the egg was not fertilized no segmentation could be expected. No other eggs of so early a stage were obtained.

II. Segmentation.

But two eggs were obtained by skimming before segmentation had commenced, the larger portion having the blastoderm well segmented indicating a development of from four to six hours. In one of these eggs which I found (fig. 4) the protoplasm was collected around one pole of the egg, imparting to it a very pale yellowish tinge and gradually fading out so that at about a third of the distance around the egg it was invisible. In this yellowish protoplasm the germinative vesicle or nucleus was visible and in these a single nucleolus. The egg measured .0375 in., the nucleus .0037 in., and the nucleolus .00055 in. Soon several strongly refractive bodies appeared in the nucleus, similar in appearance to, but smaller than the nucleolus. An unfortunate pressure of the cover glass then killed this egg, preventing any further observations upon it.

Mr. Conn however found a single egg of the same species just as the first segmentation furrow was appearing. He describes the egg as essentially similar to the one which I had, the protoplasm extending down over the yolk in a similar manner. The nucleus, however, was not visible. The segmentation furrow made its appearance at the centre of the surface of the protoplasm and gradually progressed outward and downward until the germinal portion of the disc was divided into two blastomeres. During the later stages of this segmentation the line of demarcation between the protoplasm and deutoplasm became more distinct, and at the close of the segmentation the protoplasm is gathered up at one pole of the egg as a thick two-celled cushion, as shown in figs. 12 and 13. These changes occupied about a quarter of an hour.

We made more detailed observations upon the first segmentation of the eggs of Merlucius, but as Mr. Van Vleck is intending to publish on the development of this form we do not here relate our results, simply saying that they fully agreed with the description above. This segmentation we regard as the first segmentation of the egg. That of separation of protoplasm and deutoplasm cannot be considered as segmentation, since it is one of the features of the maturation of the egg and is accomplished before impregnation.

It is to be noticed that in *all* the eggs which we studied all of the segmentation furrows, including the first, pass completely through the germinal area and in all the segmentation of the protoplasm of the egg is complete. Similar results were noticed by Van Beneden in the egg of an unknown Teleost, and by Haeckel in the egg of ? Motella. On the other hand Ellacher, Stricker (*Trutta fario*), Van Bambeke (Leuciscus), and Carl Vogt (Coregonus) describe the segmentation planes as at first passing only part way through the germinal disc.

Returning to our original egg; from the stage with four blastomeres many observations were made and all features of segmentation were verified and reverified by both of us.

[1] See preceding note.

A description of the changes undergone by a single egg will be given in detail while the variations presented by others will be noticed as occasion demands. At the close of the section on segmentation, a tabulated account of a few eggs, all apparently of the same species, will be found, with the periods of time occupied in the various phenomena of segmentation.

This egg with two blastomeres when first placed under the microscope had nuclei in each cell, though, judging from the analogies presented by the later stages as well as by the eggs of Merlucius at the same period of development, the nuclei probably did not reappear until some minutes after the first segmentation furrow was completed. Soon after this the nuclei disappeared, and in six and one half minutes afterward they were no longer visible, the first external features of cell division were noticed. A slight furrow appeared in the surface of each blastomere, their direction being at right angles to the original plane of segmentation (fig. 13). At first these furrows existed only at the junction with the primary one and were also superficial. They then gradually extended outwards and downwards from this place until in thirty seconds from their first appearance they had completely separated each blastomere into two. Two minutes later the nuclei reappeared.

In some eggs, between the completion of the segmentation furrow and the reappearance of the nuclei in the four resulting blastomeres, marked amoeboid movements were observed. In other eggs from the same lot these movements were not noticed until the blastoderm had eight blastomeres. These amoeboid motions were very marked and similar ones were noticed in connection with each segmentation from the third onward. It is difficult to describe or illustrate these motions. Processes were sent out by the cells, and furrows appeared cutting into the blastomeres, conveying the impression, the first time that the phenomenon was witnessed, that the cells were about to divide again immediately without the reappearance of the nuclei or the intervention of the usual period of rest. On the contrary, with the reappearance of the nuclei, or very soon after, these motions ceased and the blastomeres acquired their regular cellular appearance and an interval of rest intervened before further cell division began.

As was mentioned above, the same amoeboid movements were witnessed at each segmentation and in all eggs studied, and, though we are by no means positive, it seemed to us that connected with these movements was an increase in the amount of protoplasm and that particles of the yolk or deutoplasm were taken into the blastoderm. Certain observations which we made, but which are not easy to describe, seemed to admit of this and only this interpretation; and the fact that the blastoderm grows, not only in superficial extent, but also in volume, shows that the amount of protoplasm is in some way increased and thus adds additional weight to the view which we have taken. On the other hand the fact that the cells, after they have reached a quiescent state and have regained their usual smooth contours, exhibited no traces of globules or granules of yolk as would have been expected with bodies of such different refractive indices, would seem to be against this idea. It may be, however, that the deutoplasm undergoes a gradual change, and that portions of it are transformed into the substance of the intermediary layer and that the nourishment of the cells is in turn derived from the intermediary layer. That this intermediary layer contains a large proportion of protoplasm is shown by the free cell formation which subsequently occurs in it, to be described farther on.

It has been impossible to give any adequate representation of these amoeboid movements as they utterly surpass any efforts of the artist, but figs. 15 and 17 may serve to convey some slight idea of the appearances. Both are taken from blastoderms of eight cells. In fig. 17 only two cells are shown, each of which is about to segment while two processes are shown arising from one cell and *uniting* with the protoplasm of its neighbor. In this case the union was not broken until after the segmentation was completed. The other (fig. 13) represents an entire blastoderm of eight cells after the segmentation furrows are complete but before the reappearance of the nuclei.

At the time of the reappearance of the nuclei in the blastoderm of four cells, grooves were noticed extending down from the blastoderm a short distance on the surface of the yolk (fig. 14); but they soon faded out, not lasting over four or five seconds. This phenomenon was noticed at two subsequent stages; once when the blastoderm was composed of sixteen and once when of about sixty blastomeres. It may have occurred at other times but was not looked for; in fact the times when it was seen were the result of accident, it being incidentally noticed while other changes were being watched.

Concerning the internal features of the segmentation we regret that we can say nothing. Many times the nuclei of the blastoderm were carefully watched, but all that can be said is that they gradually faded away from the sight, growing less and less distinct until at last they were invisible and had utterly disappeared before the segmentation of the protoplasm began. After the cells had divided the nuclei again became visible but rather more rapidly than they had disappeared. In this disappearance and reappearance there did not appear to be any change in the size of the nuclei, but rather their optical properties more and more approximated that of the surrounding protoplasm until at last the microscope was unable to differentiate them. At no time while the segmentation fissures were being formed were the nuclei to be seen. In vain we looked for those interesting features connected with cell division which have been described in such detail by Bütschli, Flemming, Klein, Peremeschko, Schleicher, Strasburger and others. Except in the case of the maturation of the egg of Merlucius described above, we have but twice seen anything in the eggs of Teleosts which in any way even approximated an *aster*, *amphiaster* or "*spindel-kern*".[1] Once asters were seen in a large proportion of the cells of a blastoderm composed of about one hundred segments. The other time a single aster was seen among the free yolk nuclei or rather, as I prefer to call them, the free nuclei of the intermediary layer. In both cases circumstances were such as to prevent any detailed observations upon them, while the little which was seen is of no value standing by itself and hence is not described. It is sufficient to say upon this point of internal features of segmentation that in the earlier stages of division nothing comparable to the phenomena I have seen in the eggs of other forms could be distinguished without the aid of reagents, which however do not readily penetrate the envelope of the eggs which are studied. The eggs of Merlucius afford in this respect a striking contrast, as in them Mr. Van Vleck obtained by staining well marked spindel-kerne.

[1] The studies of 1882 require the modification of this statement. [illegible] I was able several times to see these structures, they being [illegible] stained by a solution of carmine in acetic acid though they did not stain with the more common reagents. The appearance of both asters (*b*) and spindelkern or amphiasters (*x*) sre shown in pl. 15, fig. 21*.

Returning to the egg whose segmentation we are discussing we have to note the succeeding features of division and first the changes in going from four to eight cells. In six minutes after the appearance of the nuclei in the four blastomeres they again disappear as before, and fourteen minutes elapsed before any further changes were visible. A depression then appeared at the middle of the inner margin of each cell and gradually extended outward and downward to the outer surface and to the yolk. These furrows were parallel to the first and at right angles to the second segmentation furrows and like them cut completely through the protoplasmic portion of the egg. The whole process of division occupied but a few seconds and the nuclei reappeared two minutes later and the blastoderm of eight cells was before us.

In the egg which formed the basis of this description the segmentation furrows appeared simultaneously in each of the four cells of the blastoderm and proceeded at nearly regular rates in all. Other eggs agreed with this, but still others (and they formed a large minority) exhibited at this early period a heterochronous division, as in proceeding from four to eight blastomeres an intermediate stage was observed in which for a few moments the blastoderm consisted of six segments, two of the cells having divided slightly in advance of their fellows. In one egg which I studied three blastomeres divided some little time before the fourth, the first three dividing simultaneously and the result was a blastoderm of seven cells. This egg presented also another peculiarity in that the nuclei reappeared at nearly the same moment of time in all of the cells and before the fourth had divided, and thus the seventh cell had two nuclei and only after the lapse of a minute and a half did this cell divide.

It was at this time, when the egg has eight segments, that we noticed the first traces of Van Bambeke's intermediary layer (figs. 21, 22, 23b). It was a very thin layer of protoplasm extending between the blastoderm and the yolk and at this stage was without the thickened margins and the free nuclei which are present in the later stages. No traces of granulations or oil globules could be seen in it. We would not, however, by the foregoing account, be understood to say that the intermediary layer made its appearance at this time, but merely that we first noticed it then. Of its time and method of origin we can say nothing except that it certainly was not present at the first segmentation of our eggs.[1]

As will be seen further on we do not agree with Van Beneden in regarding this intermediary layer as the hypoblast, but I am inclined to believe that he is correct in his idea that the tail-like processes of the cells in Haeckel's figure of an egg with two cells, in reality represent this intermediary layer. I also agree with the Belgian savant in his opinion that both Kupffer and Lereboullet observed this same intermediary layer, the statement of Kupffer to the contrary notwithstanding. Lereboullet ('51 p. 250) says "Il existe sous le blastoderm une membrane particulière, distincte, composée de grandes cellules trés pâles; c'est d'elle que se formeront les organes abdominaux". This agrees perfectly (except in regard to the last portion, the destination of the layer) with the condition of the layer in many of the fresh water fishes with numerous oil globules the "grandes cellules" being either oil globules or vacuoles. But of this intermediary layer we will speak more at length further on.

[1] I now think that this statement will have to be modified, as I regard the thin portions of protoplasm which are left extending down over the egg at the time of maturation (fig. 11), and which are also shown in fig. 12 extending out from the blastomeres, as the first traces of the intermediary layer, and the same investigations confirmed me in my belief that the layer is largely produced by the change of deutoplasm into protoplasm.

At no time after eight blastomeres were reached did the segmentation proceed regularly, and with each succeeding segmentation the irregularity became more and more marked until at last, at about that stage when the blastoderm should theoretically consist of sixty-four cells, every trace of regularity is lost and each cell divides entirely independently of its neighbors, the nuclei appearing in one just as they are disappearing in another, while a third is at the same instant dividing. In some eggs this irregularity is noticed at an earlier stage and is much more marked than in others, but in all it soon reaches such an extent that in any case it is difficult to ascertain when the theoretical segmentation is completed.

We have now to describe the division of the blastoderm from eight to sixteen cells. Nine minutes after the last mentioned reappearance of the nuclei, they again disappeared almost simultaneously, but one or two seconds intervening between the times of the first and of the last. After this disappearance and *before* the division of the cells amœboid movements, similar to those which have been described were witnessed. The cells lost their regular outlines and their smooth contours and became lobulated and furrowed. Fig. 17 before referred to represents two cells from the blastoderm. While this amœboid motion was in progress the segmentation furrows appeared. Fig. 18 will illustrate this division better than it can be described, the two interior cells divided first, then the other two, and lastly the four corner ones. The fissures in the second began before those in the first were completed and those in three before the segmentation of the second was accomplished. The complete segmentation occupied about two minutes. The planes of division were in general times at right angles with those of the preceeding segmentation and the result was a parallelogram with four cells on a side. The nuclei were again seen four minutes after the segmentation was complete and remained in sight for ten minutes. The amoeboid movements after this segmentation were very strongly marked and lasted for considerable time, and the cells did not attain their smooth contours until about the time when the nuclei vanished. The regularity of the parallelogram was far from being constant as frequently one or more cells would segment obliquely and the result would be more like that shown in fig. 19.

From this point onward the segmentation in every egg studied by us was very irregular, and by various stages of 20, 21, 28, 29, and 30 cells the theoretical 32-celled blastoderm is obtained and a short period of rest (which was not timed but which could not have exceeded three minutes) intervened after which the segmentation proceeded but so irregularly as to be beyond description. Figs. 20 and 21 will illustrate some of the later stages.

In the following table are given the results of timed observations of the segmentation of several eggs. Several others were studied but without noting the intervals between the stages. The dash (—) indicates that stage of development when the eggs were first noted and the figures the number of minutes since the last timed stage.

	1	2	3	4	5	6	7	8	9
Nuclei disappear after first segmentation (2 cells)	7			—	—		—		—
Second segmentation (4 cells)	6½			7	7½		10		8
Nuclei reappear	2						3		3
Nuclei disappear	6	—	—		8		6	—	7
Third segmentation (8 cells)	14	13	15	10	11	—	14	4	12
Nuclei reappear	2	5	6				½	4	2
Nuclei disappear	9	5	5		10	10	11	10	8
Fourth segmentation (16 cells)	9	10	11	7			7	12	8
Nuclei reappear	2	5	4	2	9	11	4	5½	3

After this stage the segmentation is so irregular that it cannot be timed

From the above table, which is based on eggs of apparently the same species,[1] it will be seen that there a considerable variation in the times which were required for the same changes in different eggs but nevertheless in many, well marked periods of rest alternating with stages of activity, may be noticed. These periods of rest and activity have recently been commented upon by Dr. W. K. Brooks ('81) and have also been noticed by many of the older embryologists in the eggs of other vertebrates and also in those of many invertebrata. I am of the opinion that these periods of (apparent) rest are thus to be explained, that at each one of them the deutoplasm, which I believe to have been taken up by the germinal area, is connected with protoplasm, and that while there is an interval of physical rest, the same time is one of chemical activity. There are several reasons for this belief, but before stating them I wish to obtain further evidence and make additional observations not only on the eggs of fishes but also on those of other animals.

The phenomena of segmentation in the eggs of Teleosts have been several times described, and the accounts which we have presented to us agree in the main with what has been given above, though there are several points of more or less importance in which differences are to be noted. The first fact which we would discuss is that the planes of segmentation even at first pass through the germinal area, cutting it completely. This is in strong contrast with the observations of most writers and so far as we are aware occurs in the eggs of all marine teleosts. Every form which we studied presented this peculiarity and the description and figures of Haeckel[1] and Van Beneden of the development of European marine teleosts. (It might here be remarked that the figures of Haeckel are highly idealistic and show many features which certainly do not exist in nature). On the other hand all writers describing the segmentation of the eggs of fresh water fishes agree in that the first cleavage planes pass but partly through the germinative disc, there remaining a portion next the deutoplasm (vitelline globe) which does not segment until much later. These facts are in strict accordance with the ideas of Balfour that eggs undergo total or partial segmentation according to the relative proportions of protoplasm and deutoplasm. In the eggs of fresh-water fishes besides the vitelline globe there is a large amount of deutoplasmic material scattered through the germinal area ; in the eggs of Merlucius there is a very slight amount in the same region, while in the eggs which we studied the protoplasm and deutoplasm appeared to be entirely distinct.

According to Vogt ('42 p. 30) the segmentation furrows do not entirely cut through the germinal area of the eggs of Coregonus until a stage with eight blastomeres is reached. To Oellacher we must refer for the most detailed account of the segmentation of the eggs of fresh water fishes which has yet been published. His observations on the segmentation of the eggs of *Trutta fario* (p. 395 et seq. pl. xxxiii figs. 18-20) agree essentially with those of Vogt but from their later date are much more valuable. He lays especial stress upon the fact that the cleavage furrows do not pass at first completely through the germinal portion, and in the later figures (l. c. figs. 22-26) he shows a layer of unsegmented protoplasm underlying the central cells of the blastoderm and continuous with the margin-

[1] These eggs as far as the microscope would show were identical, but there is a bare possibility that No. 4 which was slightly larger than the rest belonged to a different species.

This would explain the great difference in time in certain changes which here are very much accelerated.

al ones. At a later stage this lower layer of protoplasm becomes segmented. Aside from this difference, which is to be explained by the presence of quantities of yolk granules, the external features of segmentation present no important differences from our results.

The eggs of Merlucius although containing large numbers of deutoplastic globules in the germinal portion undergo a complete segmentation of the protoplasm as in that of the Cunner. There was to be noticed, however a very marked irregularity in the process of segmentation even from the very first. The blastomeres varied widely in size and the segmentation furrows progressed at varying rates and times in different portions of the germinal area.

Though we found it impossible to obtain any satisfactory sections of our eggs, their perfect transparency enabled us to see, clearly and plainly, that even the first segmentation furrow extended down to the vitelline globe and that the first two cells as well as the subsequent ones were entirely separated from each other. At no time was there an unsegmented basal portion of protoplasm except that presented by the intermediary layer and peripheral cushion of Van Bambeke.

Kupffer mentions some marked irregularities in the eggs which he studied: in some the second segmentation furrow sometimes was eccentric or occasionally was even parallel to the first. We have seen nothing of this sort in the eggs which we studied.

The theoretical segmentation of an egg is first two meridional furrows and then an equatorial one, but frequently this regularity is interrupted, in fishes noticeably so. If we interpret Haeckel aright, the equatorial furrow is the fourth to appear in the eggs of ? Motella as he figures (fig. 58) a section of a blastoderm of sixteen cells and in it lower layer cells are seen. These figures however show in every line that they are wholly diagrammatic and could not have been drawn from either actual or optical sections. In the eggs of the fresh water fishes it is at a somewhat later stage that the equatorial furrow is formed and the lower layer cells produced, but even in eggs of the same species there does not appear to be much regularity. In our eggs lower layer cells did not appear until the blastoderm was composed of about a hundred blastomeres and even then they did not appear simultaneously in all parts.

III. Formation of the Germinal Layers.

In this section we have to consider the extension of the blastoderm over the yolk from the time of the appearance of the lower layer cells until the formation of the notochord and the neural canal. In it also will be discussed the differentiation of epiblast, mesoblast and hypoblast, and also the phenomena of invagination. Certain of the features here to be described belong in part to the next section, but from the fact that they are first noticed before the formation of the notochord they are best treated here.

Until after the blastoderm has acquired a stage with about a hundred cells it consists, as before mentioned, of but a single layer, thus offering a marked contrast from the eggs of most fishes on which observations have been published. This simple condition of the blastoderm at this time was conclusively shown by optical sections in which the outlines of each cell could be readily traced with a power of a hundred and fifty diameters.

Soon after this number was reached, lower layer cells were noticed. We did not conclusively settle the manner in which they arose but are inclined to believe that the greater portion arose from the already formed cell elements of the blastoderm while possibly a small proportion had their origin in the free nuclei of the yolk. With their formation the epiblast becomes differentiated and at first consists of a single layer of cells. These cells in vertical optical section are lens shaped while the lower layer cells are polygonal in outline on account of their mutual pressure.

At first the blastoderm fits as a cap over the yolk but soon by the proliferation of cells it acquires a lenticular shape and is seated in a concavity in the surface of the deutoplasmic portion of the egg. At this time the intermediary layer (Parablast of Klein not of His) is plainly seen and its thickened margins (bourrelet périphérique of Van Bambeke) is very conspicuous. Regarding the origin of this layer we have nothing new to offer. Its first appearance was not noticed either as to the exact stage or as to the method in which it arose.[1] Neither was the time of its disappearance observed; it was visible until the blastoderm nearly covered the yolk. When first seen the layer was clear and transparent without any traces of granules, vacuoles, nuclei or cells, though at a later stage they were visible. The first observer who noticed this intermediary layer was Lereboullet who saw it both in the pike ('54 p. 248) and perch (l. c., p. 250). He describes it in the latter as follows: "Il existe sous le blastoderme une membrane particuliere, distincte, composée de grandes cellules très pâles; c'est d'elle que se formeront les organes abdominaux"; and in speaking of the pike he says that the vitelline globules are changed to this layer. Almost all subsequent observers have seen this same layer and have added to our knowledge of it. Our discussion of their results will be taken up in connection with that of the germ layers with which it is intimately connected.

At about the time of the differentiation of the lower layer cells as well as at later stages free nuclei were seen on the *surface* of the yolk. These nuclei were irregularly arranged, in fact no traces of any regularity could be discerned except that all were on the surface and now were to be seen on the interior of the yolk. (The term surface here embraces not only that portion which is in contact with the egg membranes but also that on which the intermediary layer rests). In the eggs of Merlucius at a slightly older stage similar nuclei were seen and around many of them, especially those nearest the blastoderm, the cell walls could be made out, the whole presenting an appearance somewhat similar to that given by Kupffer ('68 p. 217 pl. XVI) in the eggs of Gasterosteus. These free nuclei and cells are not arranged with anything like the regularity of Kupffer's figures. In the Cunner egg I watched the process of cell formation around these nuclei with some care. The nuclei nearest the germinal portion of the egg were the first to become the centres of cells and the formation of the cell boundaries took place in a corresponding direction, that is those portions of each cell wall nearest the blastoderm appeared first and these gradually extended themselves around the nuclei. The whole operation required over half an hour. In the Cunner but comparatively few of these free nuclei and resulting cells were seen.[2]

[1] The observations of 1882 elsewhere detailed alter this statement slightly.

[2] In 1882 by staining, these free nuclei with all their accompanying phenomena were seen and studied, fig. 21*, pl. XV, representing a portion of the blastoderm and the adjacent portion of the peripheral cushion; in the latter there being shown asters, amphiasters, and the process of outlining of the cells.

As time passes the blastoderm gradually extends itself over the surface of the yolk until, at a later stage than that described in this section, it completely embraces it, thus forming the yolk sac. When about one-fourth of the surface of the yolk was thus covered, the segmentation cavity was first noticed. No observations were made regarding its mode of origin but it was doubtless by a lifting up of the blastoderm. In the earliest stages its roof was formed by the epiblast alone, its walls of lower layer cells while its floor was formed by the yolk, or rather by the intermediary layer which rests upon the yolk. The floor at this time was perfectly free from nuclei or cells. At first the segmentation cavity is low, circular in outline, with its lateral margins about equidistant from the edge of the blastoderm. The blastoderm continues its extension over the yolk and increases rather more rapidly in one position of the margin than on the others, and at the same time the lower cells encroach upon the segmentation cavity from one side until the cavity becomes eccentric and is placed nearer one portion of the blastodermic margin than to the others. This pushing in of lower layer cells continues until the cavity acquires an arcuate or reniform outline. At this time free cells are numerous upon the floor of the cavity.

This is the first opportunity we have for the orientation of the egg. The segmentation cavity is farthest from the portion of the blastodermic margin where the first outlines of the germ are to appear and so we may now speak of anterior and posterior portions of the blastoderm, the segmentation cavity is anterior and the embryonic area posterior.

The invagination of the hypoblast now begins. As before stated we were unable to cut actual sections but the extreme transparence of the eggs rendered this almost a superfluity. Our observations on the invagination were made both by surface views and by optical sections, the latter being in almost every respect equal to actual ones while from the fact that the steady progress of the invagination could be continuously watched in the living egg they presented advantages which no product of the section knife could equal.

At all points of the margin of the blastoderm a single layer of cells may be seen pushing themselves inward beneath the rest of the blastoderm and separated from the lower layer cells by a well defined line. Between this hypoblast and the yolk is still to be found the intermediary layer. The invagination progresses much more rapidly from the posterior or embryonic portion of the blastoderm than from any other portion of its margin, and at the anterior portion more rapidly than at the sides. Fig. 22, pl. XIV, represents an optical section on the median line of an egg in which invagination has just begun, while fig. 23 represents the same at a somewhat later stage. In this last figure the extent of the lateral invagination is shown by the shaded area. Fig. 24 gives a view of the lower surface of the same blastoderm showing the rates at which the invagination progresses in different parts. (The dotted line indicates the plane on which the section described is taken.) The invagination continues until it forms a layer entirely separating the rest of the blastoderm from the yolk and intermediary layer. Its later stages and the phenomena accompanying it belong more properly to the next section.

Our attention was not especially directed toward the origin of the mesoblast but we are of the opinion that it arises partly from the lower layer cells and partly from the hypoblast. Whether it arises as two lateral plates, we know not, but at an early stage it forms a continuous layer extending across the embryonic area as shown in fig. 25. With the progress of the invagination the segmentation cavity is encroached upon by the lower layer cells, its floor becomes covered with cells, some arising from the hypoblast while others apparently originate from the free yolk nuclei, and the cavity is shortly obliterated.[1]

I admit that I am in doubt as to the part played by the intermediary layer and its resulting cells. As before mentioned a portion of the cells apparently enter into the floor of the segmentation cavity and are subsequently either embraced in the hypoblast of invagination or are crowded by it into a mesoblastic position. This however accounts for but a small proportion of the cells of the intermediary layer, and it seems to me probable that the hypoblast of invagination forms only the dorsal wall of the alimentary tract while the intermediary layer furnishes the ventral portion. This seems to be in full accord with the formation of the alimentary tract in other forms (e. g. Batrachia) where the ventral portion of the hypoblast is formed by yolk cells.

Regarding the origin of the hypoblast in the Teleosts there seems to be a diversity of opinion. Henneguy ('80 p. 402-3) describes the invagination in the eggs of the perch and trout, the blastoderm being inflected at its margin and a line or fissure separating the sensorial [our lower layer cells] from the inflected portion. So far we agree with him. He however states that the epidermal layer is not inflected. In this he agrees with two of the figures of His ('75 pl. II, figs. 2 and 3) but not with fig. 1. Our observations were that the epidermal layer of the epiblast alone is inflected. Balfour ('81, 57) says that the yolk cells form the hypoblast in the smaller Teleost eggs but that in the larger as in those of Elasmobranchs only a portion of the hypoblast has such an origin. We should consider our eggs as small. Kupffer with a doubt regards the cells as forming the hypoblast. Professor Van Beneden in his researches on the eggs of an unknown Teleost ('78) arrives at widely different conclusions regarding the origin of the germ layers from those we have formed and we cannot reconcile his results with our observations. We have seen step by step, minute by minute, the progress of the invagination and it scarcely seems possible that any error of observation on this point can have crept in, especially as we witnessed the process many times. Yet Van Beneden totally denies that in his Teleost any invagination takes place. It would seem to me that he is wrong from the very start. On p. 52, he considers the egg before the appearance of (our) two segmentation spheres as follows: "Directly after fecundation the egg of the osseous fish divides into two very unequal cells, very dissimilar, differing in constitution and significance; the one is a germ which segments and from which the blastodisc is derived; the other is formed by the deutoplasmic globe * * *. This cell is the origin of the endodermic layer of the future embryo." To all of this I must express an emphatic dissent. The aggregation of the protoplasm at one pole of the egg and of the deutoplasm at the other cannot in any way be considered as a segmentation, nor can the deutoplasmic portion be considered as a cell. No one would think of regarding a centrolecithal egg, that of a Crustacean for example, as composed of two cells or the central portion as of a cellular character, yet the homology between the two eggs is easily shown. On the same page he explictly says that the germinal portion is the homologue of the ectoderm and the vitelline of the entoderm, a view

[1] Subsequent studies lead me to believe that this statement is an error and seem to confirm the idea of Ryder with regard to this cavity, though I must say that there appear many difficulties in connection therewith.

which is not warranted without considerable qualification. It must be understood that I am not criticising his observations on the free cell formation in the intermediary layer and in the yolk, nor do I deny that a portion of the hypoblast may arise from those portions. This free cell formation we have both witnesed in the eggs of several marine Teleosts and we are willing to accept his account of their formation but I do deny that the presence of these cells and nuclei can be addressed as evidence that the dentoplasmic globe itself can be considered as a cell and the complete homologue of the hypoblast. On p. 56 he considers that the hypoblast described by Haeckel, and which closely resembles in its structure and mode of origin that of our fishes, was in reality "composed of cells derived from the intermediary layer." It hardly seems possible that there should be in the eggs of teleosts such diverse methods of origin of the hypoblast and that in closely allied forms. Professor Van Beneden following Haeckel regards his egg as probably belonging to one of the Gadidae, and with this opinion we are inclined to agree. The eggs of Merlucius and of Morrhua present a striking resemblance to those studied by Haeckel and Van Beneden, and if there be any relation between the characters of the eggs and of the fishes producing them (a point on which we have but slight data) the eggs studied by both probably belonged to the Gadidae. Now as we have observed in an egg with a conspicuous oil globule, and as has been traced through with great care by our friend Mr. Van Vleck in the egg of Merlucius, the hypoblast arises exactly as we have described it above.

It would thus appear that Van Beneden has been led into an error either of observation on his own eggs, or of interpretation of the results of Haeckel, regarding this point and we are inclined to believe that the former is the case, for the reason that it appears from internal evidence presented by the article in question that he did not witness continuously the phenomena presented by his eggs. Still there remain certain statements which we cannot reconcile with what we believe to be the facts of the case. For instance the statement on p. 56. "The blastodisc remains all this time very sharply delimited inferiorly and in no part is there a passage from one to the other (from the upper portion of the blastoderm to the hypoblast). In no part have I found the slightest indication in favor of invagination."

In the earliest stages of the egg the intermediary layer is not present but it soon appears and acquires its maximum development about the time of invagination. It appears to arise by an elaboration of the food yolk into protoplasm. It consists in our eggs as in those of Van Bambeke and Van Beneden of a thin layer extending across the egg between the blastoderm and the food yolk, and having a thickened marginal welt. This welt extends down some distance over the yolk and it may be possible that the nuclei of the yolk mentioned on p. 199 belong in reality to this extension of this layer. Klein ('72) describes this as a ring in the trout as he failed to find the portion extending across between the blastoderm and yolk.

Most observers have considered the mesoblast as arising as a continuous sheet in the Teleosts but Calberla claims that it is in two halves as in the Elasmobranchs.

We found no traces of the segmentation cavity of Van Bambeke and judging from the irregularity of his figures we are inclined with others to regard it as a product of reagents or the section knife. The segmentation cavity of Von Baer which was found in our eggs is clearly homologous with that of other forms of animals.

IV. Notochord and Neural Cord

The origin of the notochord in the Vertebrata has recently been the subject of some discussion, and though we cut no sections we endeavored to make such observations as would throw some light upon its source and the methods of its formation. All of our observations were made upon the living egg, and as we have in a single egg watched continuously every step in the process, and have several times verified all of our results, we feel confident of their accuracy as far as our fish is concerned. To sum up our studies of this point on which we both agree, *the notochord arises from the hypoblast, at first as a longitudinal median thickening of that layer and subsequently becomes segmented off and takes its place among the mesoblastic tissues.*

A detailed account of the evidence on which we base this statement will now be given. First an account will be presented of the changes witnessed in a view of the lower surface of the blastoderm and afterward a description of the phenomena observed in optical sections.

Fig. 21 represents the under surface of the blastoderm at the earliest stage at which the notochord was seen in a flat view. The segmentation cavity (*s*) possesses the arcuate outline before described while the shaded portion of the figure indicates the extent to which the invagination has extended. The embryonic area (*ea*) has encroached but slightly upon the cavity. Another sketch shows the same embryonic area on a larger scale.[1] In the median line is seen the notochord extending not quite half way from the margin of the blastoderm to the anterior extremity of the embryonic area. Anteriorly the notochord is well marked and clearly differentiated from the surrounding tissues, while posteriorly this distinctness fades out until at last no line can be drawn separating the chord from the adjacent hypoblast. Anteriorly the cells of the notochord have the same polygonal outline as have those of the hypoblast, but they are much smaller, indicating that rapid cell division is taking place. As we proceed in our examination, toward the hinder end of the notochord, we find the cells gradually increasing in size and approximating those of the lower germ layer in magnitude until at last no difference can be observed between them. Sometimes a sharp line may be seen cutting across the extreme end of the notochord and slightly in advance of the margin of the blastoderm and separated from it by a narrow strip of hypoblast, as frequently however this arcuate line was absent, but whether present or not we were never able to trace the notochord quite to the edge of the blastoderm. The margins of the chord at this stage were straight anteriorly but at the hinder end they diverged giving the whole a somewhat spatulate outline. This shape, resembling somewhat the appearance of a paddle, the blade behind, was retained until a comparatively late stage in the development.

At this stage, though the notochord was in a great portion of its length clearly and distinctly outlined, not a trace of cells could be seen extending across the ventral surface of the chord as would have been the case had it been of mesoblastic origin, for then the hypoblast would have extended over the lower surface.

As the embryo increases in size the notochord becomes longer, apparently growing in both directions but much more rapidly posteriorly, keeping pace with the extension of the

[1] In drawing the plate this figure was inadvertently omitted. It is hoped that the description is sufficiently clear to be intelligible without it.

blastoderm over the yolk. At the same time other changes may be noticed, in full accordance with the idea that the notochord arises from the hypoblast, though they are by no means the sole proof which we have to offer, as will be seen farther on. Near the anterior end of the chord, the cells of the hypoblast may be seen extending themselves across on the under surface of the notochord until these hypoblastic processes from either side meet and close in the chord. The formation of this bridge occupies but a few minutes and is first completed near the anterior portion, from which it progresses at the same time in both directions, reminding one of the closing up of the medullary groove in other vertebrates. It has been impossible to obtain any satisfactory sketch of this process as seen in a superficial view. The feature of the egg which has already been mentioned, the greater specific gravity of the germinal portion, readily permitted us to trace these various changes on the under surface of the blastoderm.

Soon the cord is anteriorly entirely cut off from the hypoblast and closed in; this process progresses more slowly posteriorly until finally the notochord is wholly separated from its parent layer and is entirely surrounded by mesoblastic tissues, but at what stage the separation is complete our notes and observations do not show. It is however before the formation of the optic lobes and protovertebrae. For a time the cells of the hypoblast can be distinguished by careful focussing extending across the notochord but soon they become so small that it is impossible to recognize them as such with the highest powers which it is possible to use in such investigations carried on upon the living egg.

This cutting off and closing in of the notochord has been several times witnessed by both of us and it seems as if there were but little chance for errors of observation, but while this observation from the surface would show that the hypoblast plays a part in the formation of the notochord it does not conclusively prove that it is the whole source of the notochordal cells. So far as these already described observations go all three of the germ layers may play a part in its formation and there might be some truth in Rudwaner's statement ('76 p. 161) that the notochord arises from the epiblast. We have however other evidence which proves to us conclusively that the hypoblast alone gives rise to the notochord.

Returning to the invagination described above; its later stages and its connection with the formation of the chorda dorsalis may now be described. These various steps have been constantly and consecutively watched by us both in several eggs, not only of the Cunner but in several other forms, as well as by Mr. Van Vleck in the eggs of Merlucius and there exists in the minds of us three not the slightest doubt of their general accuracy.

In optical sections it was seen that the invaginated hypoblast was but a single layer of cells in thickness and at all times was separated from the overlying mesoblast by a well defined line. An optical section, transverse to the longitudinal axis of the embryo, was closely watched and at first the hypoblast was but a single layer of cells deep and everywhere of uniform thickness. Soon a thickening was seen in the median line of the hypoblast, extending slightly into the mesoblast and also into the underlying yolk or intermediary layer. This thickening *was clearly a part of the hypoblast and the mesoblast was in no way concerned in its composition*, the line of demarcation between the two layers being as well defined as before. Gradually a sharp line appeared cutting the thickening away from the hypoblast (fig. 25) and succeeding this the hypoblast was seen to extend itself across beneath the now formed notochord (figs. 26—28) in just the manner which we were led to expect from our observations made from surface views.

It is always difficult to make out cell limits in optical sections of eggs as small as those on which we worked and hence they are omitted in our drawings, but it was seen that in this notochordal swelling of the hypoblast that the cells were smaller than the adjacent portion of the layer just as was seen in the surface views.

We would repeat and lay especial stress upon the fact that we witnessed, by constant and repeated observations on living specimens, every step in the formation of the notochord, from a hypoblast of but one cell in thickness until the chord was segmented off from its parent layer and eventually entirely enveloped by the mesoblastic tissues, and at no time did we witness the slightest appearance that could be regarded as evidence that any portion of the notochord was other than hypoblastic in its origin. The later history of the notochord will be treated under the respective sections of the development of the fish.

Previous to Balfour's first paper (Quarterly Journal of Micr. Science, 1874) all writers on vertebrate development had regarded the notochord as belonging not only in position but in its method of origin to the mesoblastic tissues. Dr. Balfour there and also in his complete monograph ('76[b]) showed that in the Elasmobranchs, at least, the notochord is a hypoblastic structure in its origin. Following him, Hensen, in a paper on the development of the rabbit, gives the same general account of the derivation of the chorda dorsalis with only such variations as might be expected in two diverse classes of Vertebrata. Calberla ('77) studying Petromyzon, Sygnathus and Rana arrives at similar results and was the first to show that in the Teleosts the notochord is an endodermal structure. Rudwaner ('76) in a short paper also treats of the origin of the chorda dorsalis, but his article is of little value and his figures are evidently diagrammatic and do *not* represent the true state of affairs. He derives the notochord (p. 161) from the outer germ layer or epiblast. More recently Braun, in his paper on the development of Parrots in the Arbeiten a. d. zool. zoot. Inst. zu Würzburg (the exact reference to which I have not at hand), still considers the notochord as of mesoblastic origin. All of these observers have worked with and studied sections and hence the discrepancy in their results. On the other hand our observations were made on the living embryo, and hence we *saw* the organ formed and did not have to call upon the imagination to fill up any gaps and also the sources of error in interpretation were eliminated.

In the development of the neural canal the Teleosts present a marked contrast according to all observers with the other vertebrates in that it is first formed as a solid cord in which a lumen afterwards appears.

At about the same time that the notochord was first seen the first appearances of the medullary folds were witnessed. Coincident with the invagination of the hypoblast the edge of the blastoderm increases in thickness and this thickening is most marked at the posterior margin in the median line forming what Balfour has called the tail swelling. When first noticed it presented much the appearance of the "stage A" of Dr. Balfour's Elasmobranch ('76[b] pl. VI, fig. A). This soon became elongate and more and more prominent until a broad shallow longitudinal furrow finally made its appearance dividing it into two lateral halves. These halves are the medullary folds and are low rounded ridges. With the increase in size of the blastoderm and the growth of the now outlined embryo, the folds anteriorly came closer and closer together and the medullary groove narrower and proportionally deeper. It then grew more and more shallow, its decrease in width also continuing until at last the groove was entirely obliterated. This groove is shown in fig. 28.

As before mentioned it was very difficult to obtain surface views of the blastoderm and hence our surface observations on the closing in of the medullary folds have not that detail which we could wish. Were an egg so held that the blastoderm was uppermost, be the pressure never so slight, it almost immediately died and then contracted so that no consecutive studies could be made. Enough, however, was seen to show that there was none of that infolding and direct formation of a neural canal which is so familiar in the other vertebrates. It was not seen whether the modified closing up took place near the middle and extended both ways or whether from the anterior end backward. From what we know of other forms the former would seem the more probable.

Fig. 28 shows an optical section through the hinder part of an embryo of the stage shown in fig. 34. Here the medullary groove is shown broad and shallow, the notochord has been separated from the hypoblast but has not attained its later quadrate section but still retains the flattened outline; the muscle plates on either side have not yet been differentiated from the mesoblast, while the hypoblast extends across immediately beneath the notochord and is not separated from it by any intervening mesoblast. In this optical section it was not possible to make out clearly the cell boundaries although the limits of the various germinal layers were readily made out as figured.

As to the method in which the neural canal forms, whether in the normal way by an actual enclosing of a tube of epiblast cells, or as maintained by Calberla by a lumen forming in the epiblast which is pushed down and not infolded, our observations will not allow us to decide, though I am inclined to believe that the latter is the method, and for this reason. The earliest optical sections of the neural cord do not show any traces of a medullary canal while at a later stage such a canal is found. The same is also true of the brain and the optic lobes. It will readily be seen that, if either of these methods be the true one, the canal so formed is perfectly homologous with the same structure in other vertebrates and hence the actual manner of its formation has not so much importance. It is however interesting to observe that there is the same formation of medullary folds in our fish as are found in other vertebrates, that they arise the same and only differ in the details of the formation of the canal. As was said above these medullary folds exist, but at no time did we see any closer approach to the formation of a closed tube by a longitudinal union of the summits of the neural folds than that shown in fig. 28. Still I am inclined to believe that a large hiatus in our observations may exist here. In a dorsal view of the tail of an embryo with about twenty protovertebrae a well-marked median line was observed which at the posterior extremity slightly broadens out into a groove, just as would be the case did the neural canal form as in other vertebrates.

Not having witnessed the formation of the neural canal of course nothing definite was seen of a neurenteric canal of the same character as exists in the Elasmobranchs, Batrachia and birds. In figure 30 which represents the first formation of the neural folds a slight notch is seen at the posterior margin of the blastoderm which afterward became much more marked. This notch arises in the same way and to my mind is homologous with the canal connecting the neural and alimentary canals which has recently been demonstrated to exist in all vertebrates. An unfortunate accident occurred to the egg forming the subject of this figure and hence no consecutive observations were made upon it. No other eggs in such favorable conditions were found. In fig. 30 I have shown the medullary folds extending slightly farther over the deutoplasm than does the rest of the blastoderm, and between them the medullary groove, the epiblast of which of course forms the lining of the neural canal. Continuous with the epiblast which passed down into the notch between the medullary folds is the hypoblast which extends up the under surface of the blastoderm. Whether this notch eventually closes up leaving a tube connecting the neural and alimentary canals I do not know, but it seems impossible to escape the conclusion that it well represents the neurenteric canal of other forms although the enteric canal of the fish does not at this time have the closed condition which obtains in other forms.

According to various observers, before the formation of the neural canal the epiblast separates itself into two layers, an outer or epidermal and an inner or nervous layer, the latter being confined more closely to the embryonic area. This differentiation we were not looking for and hence no allusion to it appears in the foregoing account of the formation of the neural cords; whether it exists or not we cannot positively say though it probably does and was overlooked in our studies. According to those observers who make this distinction, the nervous layer forms the bulk of the neural canal and Calberla ('77) claims that a thin layer of epidermal cells penetrates into the nervous layer and eventually forms the epithelial lining of the neural canal, but Götte ('78) denies this and Balfour studying Lepidosteus and the teleosts ('81) has not been able to confirm Calberla's observations. It would however seem probable that Calberla is right though farther observations are necessary to settle the point.

Schapringer ('71 p. 555) does not afford any information on this point, for he merely states that the medullary canal does not form in bony fishes, as in Birds, Batrachia and Mammals by a folding in of the medullary folds but through a process of separation on the inside.

According to our observations the method of origin of the neural ridges has an almost exact parallel in that of the Elasmobranch as given by Balfour ('78) and also closely resembles Klein's observations on the trout '62 pl. 17, fig. 2. The figures of His, ('75) in text, and which are copied by Balfour, '81 fig. 33, are greatly different from anything which we have seen as will be noticed on an inspection of our plates.

Optic Bulbs and Protovertebrae.

Shortly before the stages shown in figs. 29 and 32 the fore-, mid- and hind-brains are differentiated and almost immediately the optic lobes begin to be segmented off. At this time both the brain and the rudimentary lobes appear to be solid bodies without any internal cavity nor does there appear to be any trace of the neural canal in the spinal cord. A fissure appears on either side of the brain cutting off a portion which forms the optic lobe. This fissure begins above and behind and gradually extends forwards and downwards until at last but a slight connection is left, the rudimentary optic nerve (fig. 36). The fissures progress until at last the nerve going to the right eye is connected only with the left side of the brain while the optic nerve of the left eye arises from the right side of the same central organ, the condition which obtains in the adult fish. During the differentiations thus described other changes take place, and before the stage represented in fig. 42 is reached the lumen in the brain, optic bulbs, and neural cord appears as shown in figs. 36 and 45.

Synchronous with the differentiation of the regions of the brain, the mesoblast adjoining the notochord (fig. 32) becomes separated from the rest of the layer as the muscle plates, and with the separation of the optic bulbs the muscle plates are divided into protovertebrae. The first of these protovertebrae to be formed is at about the middle of the body, and the fissures which limit it arise simultaneously. They begin close to the notochord above and progress outward and downward and at the same time slightly backward. From this central one the formation of the protovertebrae extends gradually in both directions. At the same time the formation of pigment cells is seen. These arise as black dots and gradually increase and change their shape until at last they assume forms like those shown in fig. 51.

Regarding the peculiar structure which from its first describer we may call Kupffer's vesicle I have but little to say. It first makes its appearance just before the stage shown in fig. 34 on the under surface of the posterior end of the embryo and rapidly increases in size until it acquires a diameter nearly equal to that of the fish. Of its subsequent fate our notes afford no information. Its first appearance is indicated by one or two small globules which soon are joined by others until an appearance like that of fig. 52 is seen. Very soon these globules unite and in two hours the vesicle has the appearance and relative proportion of fig. 53. Fig. 54 shows about the limit of its development and is reached in about five hours from the first appearance of the minute globules.

As mentioned above, this vesicle was first noticed by Kupffer ('68) and by him regarded as a rudimentary allantois. Balfour ('81) regards it as homologous with the terminal vesicle of the post-anal gut of Elasmobranchs. On the other hand Henneguy ('80) studying the perch thinks he saw an opening or traces of invagination of the vesicle and would homologize it with the primitive intestine of the Cyclostomi and Batrachia and its opening with the anus of Rusconi, a view which it seems to me is entirely unwarranted by the previous growth of the embryo and by the method of origin and position of the vesicle as we have seen it. The view of Balfour seems much more probable.

The epiblast over the optic lobe begins to thicken to form the lens of the eye when sixteen protovertebrae are outlined. This thickening increases until soon it acquires the character shown in fig. 49 and almost immediately the thickening begins to be segmented off and to make its way into a depression in the optic lobes and to acquire more and more of a spherical character as shown in figs. 55-57. The manner of the involution of the lens and the features connected with it have so often been described that it is unnecessary to repeat them here.

At about this time the mesoblast begins to split into somatopleure and splanchnopleure. This splitting begins at the head end of the embryo and progresses regularly in every direction. This is a true splitting and not as suggested by Mr. Ryder in a letter to the author an apparent one. He interprets his observations as follows: the portion of the mesoblast which extends down over the yolk is that portion which eventually forms the splanchnopleure and that the somatopleure gradually extends down between this layer and the epiblast, and he also ('81) regards the space into which the somatopleure thus forces itself as the remains of the segmentation cavity. So far as our eggs and our observations go there is not the slightest evidence in favor of either view, for the epiblast is everywhere in close connection with the mesoblast and nothing could be seen in the envelopes of the yolk which could in any way be interpreted as remains or derivations of the segmentation cavity, a cavity of which all traces are lost at an early stage in the development. In our eggs also there was a veritable splitting of the mesoblast as will be seen by an inspection of fig. 36.[1]

From this point on my observations are exceedingly fragmentary and the account would best be confined to little more than the remaining figures, a course of procedure which will serve to connect the early stages with those of which Mr. Agassiz treats.

In a side view, at first but two of the prominences of the brain are seen (fig. 33) but soon the third, the mid-brain, makes itself visible as shown in fig. 34, and at the latter stage we first find the traces of the pericardium and the heart (*p*. fig. 34). Of the origin of these portions of the anatomy I can say but little. It seems almost impossible to correlate the steps of their development with those found in other vertebrates. At first there appears a mass of mesoblastic tissue arising almost beneath the hind brain and projecting into what has previously been regarded as the cavity produced by the splitting of the mesoblast (and therefore corresponding to the pleuroperitoneal cavity of other vertebrates) but which is regarded by Ryder as the segmentation cavity. (We shall return to this cavity further on). This mass of cells grows downward and when it comes in contact with the lower layer of cells (either hypoblastic or sphlanchnopleuric) a lumen appears, the primitive heart. At first this is a simple tube and indeed for a considerable time retains that character as shown in figs. 40 and 50. When the heart first begins to pulsate the vibrations are very slow and frequently it ceases beating for some time and then begins again. Coincident with the first pulsations, which appear at a little later stage than that represented in fig. 43, the first motions of the embryo are seen, and consist of slight tremors of the whole body. At first the contractions of the heart produce no currents of blood nor in fact are any corpuscles to be seen. In the eggs of the cunner it is extremely difficult to trace the development of the circulatory system after this time, only slight and unsatisfactory views of portions being visible, while only once was I able to see anything whatever of the blood vessels of the yolk sac. Of the formation of the corpuscles nothing was seen nor were they visible until a comparatively late stage.

We have seen in preceding pages the method of formation of the hypoblast of the alimentary tract by an invagination to which are possibly added cells from the intermediary layer. A portion of the hypoblast eventually forms a solid cord extending along beneath the body but of the exact method we are not certain. This cord gradually grows forward and at intervals a lumen appears, as shown in fig. 33 *me.*, the future cavity of the canal; this is shown again at a later stage in figure 42, which represents the hinder end of the mesenteron of a fish about as far developed as shown in fig. 43. Though the exact process of the closure of

[1] The investigations of 1882 which embraced these points lead me to regard Mr. Ryder's conclusions more favorably, and though I am not ready to accept them wholly without some modification, the changes required are far less than those implied in the above paragraph which is based upon some erroneous interpretations.

the blastoderm was not seen, the writer feels confident that the posterior end of the alimentary tract arises in the normal way by an invagination of the epiblast to form the proctodeum (fig. 41) and that the division between the two portion breaks down, the result being as shown in figures 44 and 53. Ryder seems to regard this proctodeum as the neurenteric canal. The steps between these two figures were all seen, but the formation of the anterior end of the canal was not witnessed. There are many points of the alimentary tract upon which additional information is needed: the manner of the formation of the mouth, the connection, if any exists, between the yolk sac and the stomach or intestine, and the relations of what is here called the hypoblast of the yolk sac to that of the digestive portion. There are many points in connection with this latter which are absolutely unintelligible to me no matter how looked upon. In fig. 33 this layer is represented as extending beneath the embryo and nowhere united with the alimentary canal and together with another layer starting off on its course around the yolk. Now if this be the hypoblast from which the digestive tract arises, some connection would be expected between them though none has been found.

The fins which are first seen in an egg about as far advanced as fig. 51, arise in the cunner as a simple outgrowth and not as a continuous lateral fold, as is found in many forms. The first skeletal elements appear as a small body at the base of the fin parallel to the body axis and it is not until considerable later that radial portions appear. This basal skeleton instead of appearing as a pair of rods as described by Ryder was rather a broad plate with a central opening, as if his rods had united at their extremities. The same feature was seen in Lophius.

The remaining features of the development so far as I have clearly made them out can be seen from the plates, and my knowledge is too deficient to say more concerning them than will appear in the explanation of the figures. In about two days from impregnation, the fish hatches with a large yolk sac, which in four days more has almost entirely disappeared as shown in fig. 53. The time of hatching I cannot exactly state, in fact it varies considerably with the temperature. Eggs which were impregnated Friday morning at ten o'clock were found hatched Sunday at eleven A. M. (How much before that hour the actual hatching took place I cannot say). The act of hatching was often witnessed. The membrane of the egg, yielding to some violent struggles of the embryo bursts open and the young fish emerges usually head first. At the time of hatching the young fish is about a tenth of an inch in length and very slender in proportion.

Explanation of Plates.

a. anus.
al. alimentary canal.
ao. aorta.
aud. auditory vesicle.
b. blastoderm (in fig. 24* an aster.)
bc. buctus Cuvierii.
ch. notocord.
ea. embryonic area.
f. fin.
f. b. fore-brain.
f. v. fin vein.
g. gills or gill arches.
h. or *hy.* hypoblast.
ht. heart.
h. b. hind-brain.
i. intermediary layer (in fig. 40 jugular vein.)
j. jugular vein.
l. lens.
l. t. thickening of epiblast for lens of the eye.
lr. liver.
mb. mid-brain.
me. mesoblast (mesenteron in figs. 33 and 41.
n. p. nasal pits.
n. g. neural groove.
o. eye.
op. optic vesicle.
o. g. oil globule
p. pericardium.
pc. cardinal vein.
p. g. polar globule.
pr. proctodeum.
p. v. protovertebrae.
s. segmentation cavity.
so. somatopleure.
sp. splanchnopleure.
su. v. superior vertebra.
s. v. sinus venosus.
t. s. tail swelling.
u. Kupffer's vesicle.
u. g. urogenital apparatus.
y. yolk.
y. s. yolk sac.

PLATE XIV.

Fig. 1. Micropyle of egg of Ctenolabrus in section.
Fig. 2. Surface view of same with surrounding pore canals.
Fig. 3. Merlucius the germinal disc above showing the archamphiaster of maturation.
Fig. 4. Early egg of Ctenolabrus before maturation and impregnation.
Fig. 5. Portion of germinal area of egg of Merlucius with probable polar globules.
Fig. 6. Formation of polar globule and expulsion of same through the micropyle.
Fig. 7. The same a few seconds later; in these two figures the details of micropyle are omitted.
Fig. 8. A polar globule attached to one cell of a blastoderm of two segments.
Fig. 9-10-11. Three successive steps in the formation of the biscuit-like germinal area, shown in section, the shaded portion extending out from that region forming a portion of the intermediary layer.
Fig. 1.. Result of first segmentation, the "tails" on either side the rudimentary "bourrelet périphérique."
Fig. 13. Preparations for second segmentation.
Fig. 14. Resulting four segments with the temporary furrows of the yolk.
Fig. 15. Diagram of amoeboid motions in blastoderm of eight cells.
Fig. 16. Blastoderm of eight cells showing a common irregularity.
Fig. 17. Amoeboid appearance of two cells.
Fig. 18. Preparation for dividing from eight to sixteen cells, showing irregularity in time of division.
Fig. 19. Blastoderm of 16 cells.
Fig. 20. Blastoderm of 24 cells.
Fig. 21. Optical section through the edge of a blastoderm in a late stage of segmentation.
Fig. 22. Beginning, and fig. 23, later stage of invagination of hypoblast. The upper shaded portion representing the epiblast and lower layer cells; *s*, the segmentation cavity, and the dark narrow line just beneath, the intermediary layer; the broad shaded portion shows the outline of the lateral invagination. The black line beneath *h*, the hypoblast, and *e. a.*, embryonic area is possibly the segmentation cavity of Ryder.
Fig. 24. Blastoderm of fig. 23 from above, showing the outline of the segmentation cavity, the line across shows the plane of the preceding section.

PLATE XV.

Fig. 24*. Cells from the margin of blastoderm; and beneath, free cell formation in peripheral cushion; amphiaster *x*, and an aster *b*, are shown and also a stage in the formation of cell walls.

Figs. 25, 26 27. Three stages in formation of notochord shown in (optical) section.

Fig. 28. Same at later stage.

Fig. 29. Side view of embryo, etc., showing the blastoderm with (faintly) its thickened margin.

Fig. 30. Oblique view of tail end of fig. 29, showing the neural groove, the tail swelling and the thickened margin of the blastoderm, the slight notch in the margin at *t s* may possibly represent the neurenteric canal.

Fig. 32. Formation of optic lobes and protovertebrae; the apparent distortion of the figure is due to an attempt to represent the embryo in perspective.

Fig. 33. Stage a little later than 32 showing optic lobe and mesenteron and a few of the anterior protovertebrae.

Fig. 34. Still later with fore-, mid- and hind-brain differentiated and pericardial region forming.

Fig. 35. Splitting of mesoblast into somatopleure and splanchnopleure.

Fig. 36. Dorsal view of head a little later than fig. 34 with formation of the lens of the eye and the appearance of the lumen in the brain and optic vesicles.

Figs. 37. 38, 39. Successive changes in appearance of notochord.

PLATE XVI.

Fig. 40. Heart and blood vessels in stage nearly corresponding with fig. 51, or shortly before hatching.

Fig. 41. Relations of notochord, aorta, urogenital canal, mesenteron and proctodeum in hatched fish.

Fig. 42. Lumen in mesenteron in embryo about like fig. 43.

Fig. 43. Embryo with the lens of the eye, auditory vesicle and nasal pits well advanced. The blastoderm has closed and the tail has begun to grow out. Kupffer's vesicle was present but is omitted in the drawing.

Fig. 44. Anal region in hatched fish.

Fig. 45. Details of head in fig. 43.

Figs. 46 and 47. Out-growth of liver in its earliest stage from the side and from beneath.

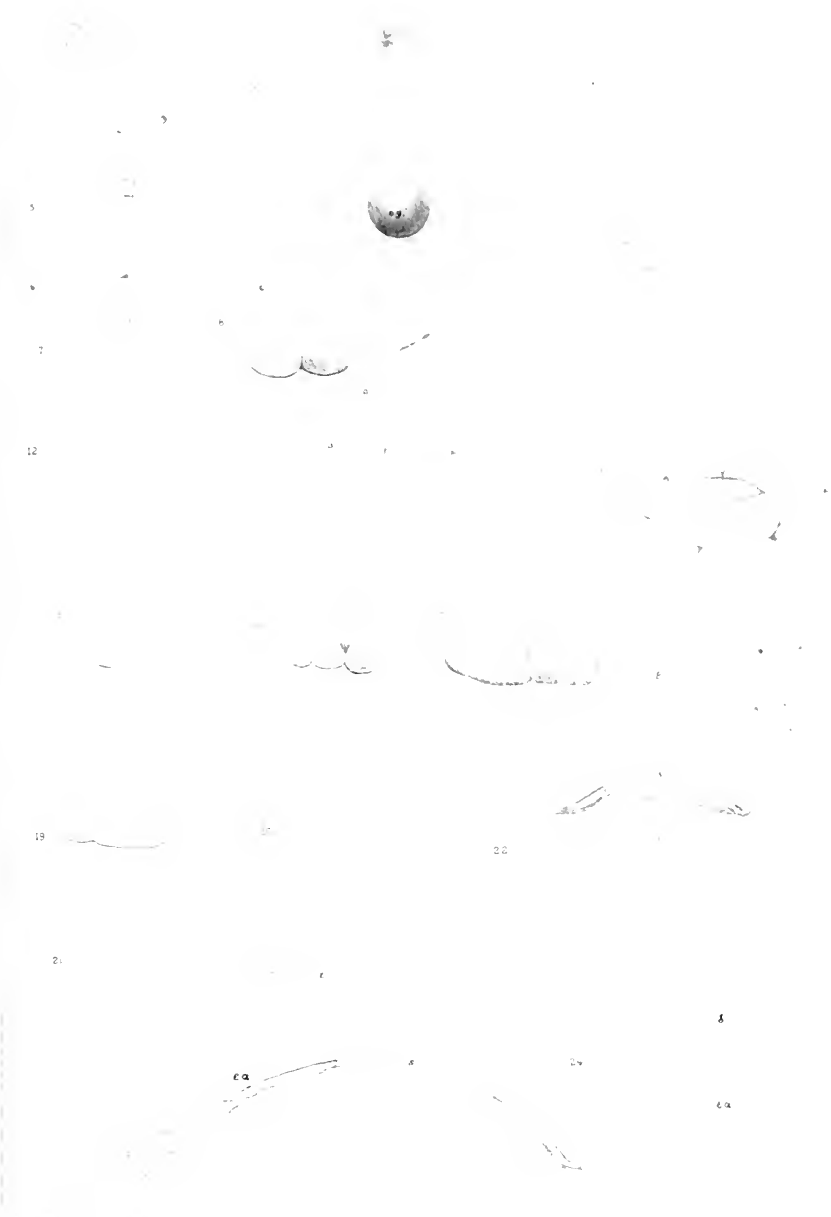
Fig. 48. Anterior portion of fish two days old from beneath, showing anterior end of urogenital canal. The stomodeum and mesenteron have not yet met. H. W. Conn, del.

Figs. 49 and 50. Fish of about four days. H. W. Conn, del.

Fig. 51. Embryo of unknown teleost just before hatching.

Fig. 52 and 54. Two stages in formation of Kupffer's vesicle, *u*, seen in optical section.

Fig. 53. Fish between four and five days old.



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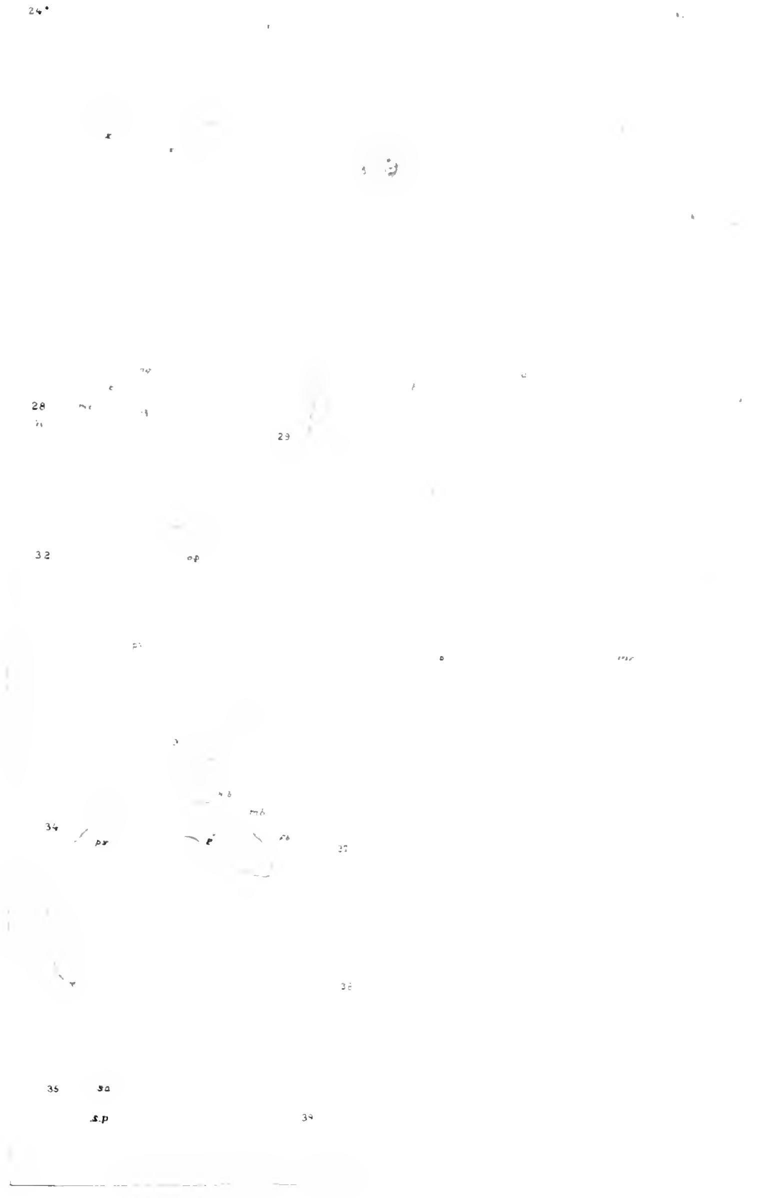
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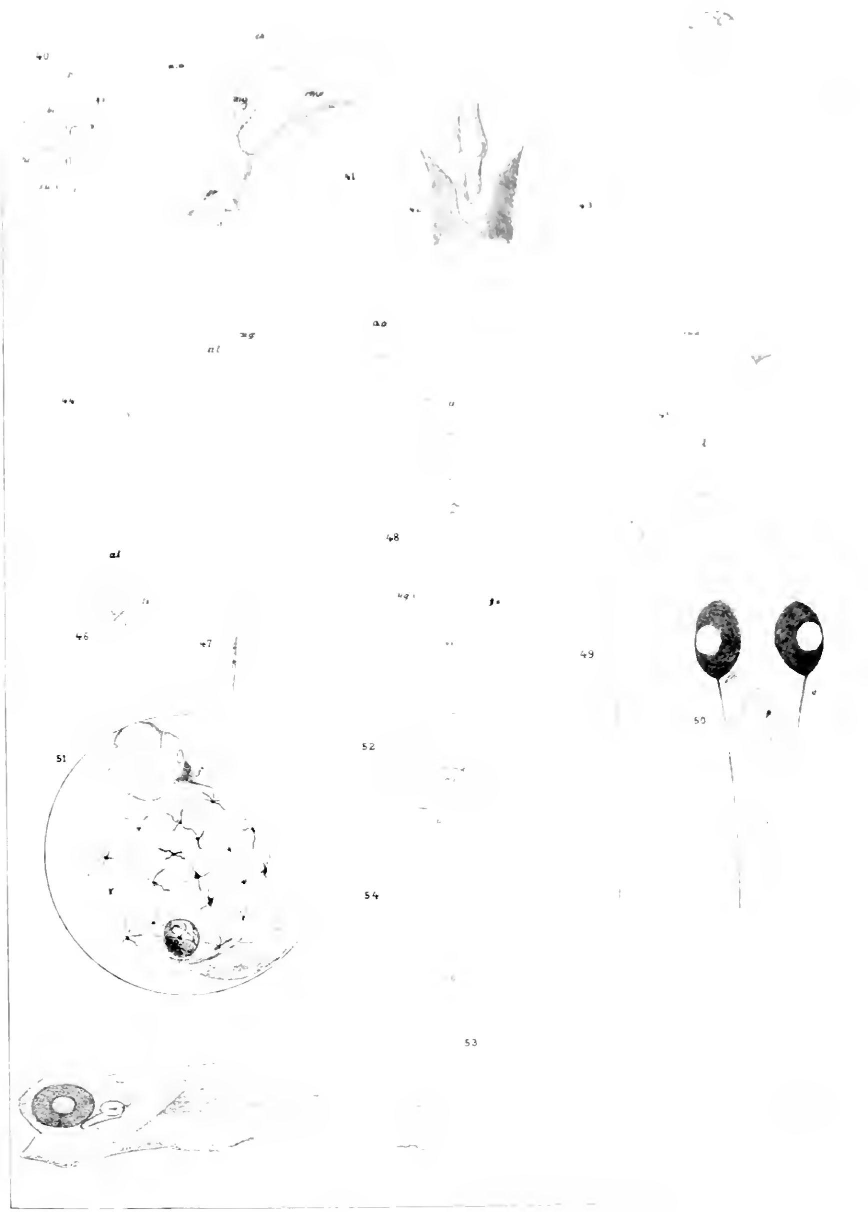
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VII. The Carboniferous Hexapod Insects of Great Britain

By Samuel H. Scudder.

Read May 24, 1882.

Although it is very nearly fifty years since Audouin first announced the discovery of insect remains in the coal-measures of England, the number of known forms from that country is still so small that they may be counted upon the fingers of one hand. The addition of two species to that number, which I am able through the kindness of Rev. P. B. Brodie to make at the present time, is therefore of more than common significance. Each of these, moreover, has a special interest, the one from its striking color-contrasts, the other from its gigantic size; and both throw so much new light upon the ancient insect fauna of Great Britain that I venture to pass all the neuropterous forms under review, partly to clear away certain misapprehensions concerning the affinities of those that have been described, partly with the view of vindicating the accuracy of Audouin's early announcement; partly also in the hope that this may lead to the discovery of more forms in these older beds, where every addition to our knowledge is likely to be of more than ordinary importance.

Both the additional forms represent genera hitherto unknown, as do also each of those already described. To the first of the new types we may apply the generic name

Brodia nov. gen.

In this genus the wing is long and slender, shaped somewhat as in Panorpa, slightly pedunculated at the base; the costal margin is nearly straight, being very gently and and equably convex, the lower margin moderately full, straight along the middle portion. The marginal vein forming the border is stout, armed throughout with short prickles or spines (pl. 17, figs. 5, 6). The mediastinal vein is the most indistinct in the wing and situated at a low level (compare pl. 17, fig. 3 and fig. 4); it runs midway between and entirely parallel to the marginal and scapular veins until near its extremity, where it turns upward very gently, terminating in the margin at about the middle of the wing. The scapular vein runs parallel to the margin throughout the wing (as preserved; that is, nearly to the tip) and is situated at a high level; its main branch, which is again at a low level, parts from the vein at an exceedingly slight angle at the end of the basal fifth of the wing, and runs parallel to the main vein, and at a distance from it about equal to the distance of the latter from the margin; this main branch emits half a dozen or more equidistant, oblique veins from its lower side (five are found in the fragment), which run parallel to each other toward the outer part of the lower margin; the first of these nervules is at a high level, is thrown off near the base in continuation of the base of the main branch and is more curved than the others, its basal direction being less oblique than theirs. The externomedian vein is a simple, gently arcuate vein, running from the base to a little beyond the middle of the lower margin, and emitting from its upper side at the middle of its course a single branch, arcuate at base, which, like the main vein, has a course parallel to the scapular branches; both main vein and branch are situated at a very low level. The internomedian vein is nearly straight, a little arcuate, especially in the apical half, and perfectly simple, situated at a high level and terminating a little before the middle of the lower margin. The anal vein, neither elevated nor depressed, is forked at the base, one fork running parallel to the internomedian vein in the basal half, and beyond curving downward to the margin, which is slightly indented at this point; and the other again forking, the forks similar, curving, but very short.

There are several distinct cross-veins in the wing; one important one, a long and curving vein, connects the externomedian and scapular vein, near the base, and appears to form a downward curving basal continuation of the main branch of the scapular, making it look like a superior branch of the lower vein; the others are transverse and most of them at exactly right angles to the nervures, and they are all situated in the dark bands. Besides these, there are a large number of fainter cross-veins transverse to the nervures they connect, pretty regularly and uniformily distributed over the wing below the main scapular vein, forming quadrangular cells which over most of the wing are more than twice as broad as long.

The genus is dedicated to my honored friend Rev. Peter Bellinger Brodie; as his name will always be connected with the fossil insects of England, it is fitting that so notable a form as this should recall his eminent services.

This generic type is an ancient form of Planipennia or true Neuroptera, the structure of whose wings does not agree with that of any of the existing families of the group, but rather shows a combination of features which now distinguish separate families. It has the general aspect of a gigantic Panorpa, borrowed from its form, its markings, the presence of a few scattered cross-veins, and the course of the mediastinal nervure. When, however, its neuration is carefully observed, the scapular vein is seen to be fundamentally different, although its position and the origin of its main branch is similar; for, while in both cases the area it occupies is important, in the Panorpina the main branch divides dichotomously throughout, and its offshoots take a longitudinal direction; while in Brodia, the main branch emits oblique shoots at regular intervals downward and outward, as it does in other Planipennia, but not in Panorpina. The veins below the scapular are also very different from what they are in Panorpina, and relatively to the rest of the wing much less important.

With the Hemerobina, the wide space between whose marginal and mediastinal veins is filled with numerous oblique and generally forked veinlets, and whose scapular vein has numerous sectors, this ancient type has less to do. In this group the mediastinal vein extends nearly to the tip of the wing, while in Brodia it terminates a little beyond the middle. The Hemerobina, however, differ from other Planipennia in the insignificant part usually played by the externomedian vein, which is frequently almost entirely simple or only forked once in the apical half of its course. This peculiarity is borrowed, though not in a striking degree, by Brodia, where this vein is forked once near the middle, but whose branches, widely distant like those of the scapular vein, cover a considerable area.

The more essential features of this ancient wing, however, foreshadow the characteristics of the Sialina. In form, while it is not very different, it has none of the arching of the costa almost universal among Sialina, and usually accompanied in modern types by a broad space between the marginal and mediastinal veins, not at all displayed by Brodia. In the brevity of the mediastinal vein Brodia resembles the Raphidiidae, but the neuration of the rest of the wing is completely different; while in the Sialina proper the mediastinal vein always continues nearly to the tip of the wing. The course and distribution of the branches of the scapular vein, however, are of greater importance, and in this respect Brodia agrees very well with the Sialina; again, however, the simplicity of the internomedian vein in Brodia, where it consists of only a single undivided ray, is very different from that now found in Sialina, where it is always divided and often plays a somewhat important part.

Brodia, then, is a planipennian in a broad sense, refusing to affiliate closely with the restricted families of the present day. Nor does it appear to be intimately related to any paleozoic insect yet described. It is also peculiar for possessing a very large number of fine cross-veins or wrinkles, besides the stout cross-veins which are scattered here and there over the wing; the latter are, however, confined to dark patches to be mentioned presently; while the former are uniformly distributed over the wing, subequidistant, and always run at right angles to the nervures they connect, even where, by keeping that course, they strike the often obliquely directed, stouter cross-veins.

In the preservation of its colors (pl. 17, fig. 7), Brodia is the most striking instance known among paleozoic insects the markings are sharply defined and, to judge from illustrations, more deeply tinted than in *Protophasma Dumasii* recently described by Brongniart, who has drawn particular attention to this remarkable feature in the wings; or than in the longer known *Gryllacris lithanthraca* of Goldenberg. In allusion to this colorational feature, the species may bear the name of

Brodia priscotincta nov. sp.

Pl. 17, figs. 3-7.

The wing is a rather large one, being probably about 55 mm. long (the fragment is 14 mm. long) and 12 mm. broad in the middle. Both front and hind margins are very dark colored and are distinctly furnished at the extreme edge with a row of fine bristly teeth, short, stout, triangular, pointed, black, directed outward and forward (or backward), and on the costal edge more closely approximated away from (pl. 17, fig. 5) than near (pl. 17, fig. 6) the base; beyond the base, also, the marginal vein is furnished along its lower edge with a similar armature, only the teeth, here also black, are depressed, directed outward, and not nearly so sharply pointed (pl. 17, fig. 5).

The stone on which the wing is preserved is of a dull, impure gray color (pl. 17, fig. 7), and the hyaline parts of the wing do not differ from it in tint. Nearly half of the wing however is of a much darker shade, the markings consisting mainly of three broad transverse belts, which cross the wing from the scapular vein to the lower margin, one near the middle of the wing and one near the middle of either half; these, and especially the outer two, are of a distinct though dull umber brown; the same deep tint is also found throughout the space between the scapular vein and its main parallel branch, but the whole costal margin above the scapular vein is hyaline; the apex of the wing, which is lost, was probably tipped with the dark color. Of the three transverse belts the outermost is pretty regularly transverse, its inner margin following an irregular zigzag course, generally at right angles to the costal margin, from the base of the third offshoot of the main scapular branch to the tip of the lower externomedian branch; its outer margin follows a similar direction downward from the base of the fourth offshoot of the main scapular branch, until it reaches the second offshoot, when it follows that outward (to the broken part of the wing). The middle transverse belt is less regular, being nearly broken in the middle, its lower half hardly more than half as broad as its upper half and thrust a little further outward; the upper half is seated on the extreme base of the upper externomedian branch and, broadening upward, reaches from near the base of the first offshoot of the main scapular branch to nearly midway between the second and third offshoot; the lower half is equal and tolerably regular, its middle line opposite the lower termination of the outer margin of the upper half, its outer margin terminating below at the tip of the internomedian vein. The inner belt is broken into three fragments; the upper, between the scapular and externomedian veins, reaches from where these veins begin to diverge to the extremity of the curved cross-vein uniting the two veins; the second, between the externomedian and internomedian veins, extends in neither direction so far as the one above, and is terminated outwardly by a distinct and oblique cross-vein; the third occupies the outer half of the anal area. Besides there are a few dark cloudy spots at the base, one following the lower edge of the internomedian vein, and others parts of the anal veins.

The heavier cross-veins, besides the one referred to in the generic description, at the base of the main scapular branch, are the following: In the scapular area, four equidistant transverse veins between the main stem and the main branch; two approximate transverse veins between the third and fourth offshoots of the main branch,— both in the outer dark belt and the outer forming its outer margin; one in the same belt in the interspace below, and in continuation of the inner of the transverse veins above it; one in the middle belt, oblique to the nervures but at right angles to the costal margin, between the scapular and externomedian veins; two others in the same interspace in the outer belt, a little oblique to the nervures, in the opposite sense to the preceding; two others in continuation of these, but transverse to the nervures between the externomedian branches; another in the same interspace in the middle belt, also transverse; one in continuation of this, in the interspace below, forming the inner margin of the middle belt, besides another outside of it in the externo-internomedian interspace, both transverse, and one in the same interspace, very oblique, forming the outer margin of the inner belt; two in the interspace below, one oblique, its lower extremity at the tip of the anal vein, the other transverse, above the middle of the lower spot of the inner belt; and finally one, very oblique, in continuation of the preceding. It thus appears that all the heavy cross nervules fall in the three transverse dark belts and that with few exceptions those which are oblique to the neighboring longitudinal nervures are situated in the interspace between main veins, while those which are transverse are between branches of a single vein.

The specimen comes from the coal measures near Tipton, Staffordshire, where it was obtained by Mr. C. Beale and was kindly sent to me for study by the Rev. P. B. Brodie, Vicar of Rowington, near Warwick, to whom it now belongs. The face examined is the upper surface of the right wing, or else the reverse of the lower surface of the left wing.

The second species may be called:

Archaeoptilus ingens nov. sp. et gen.

Pl. 17, figs. 10-12.

The costal margin, or marginal vein, is pretty strongly convex at the base, but beyond is straight; no other margin is preserved, and only the base of this, but the wide separation and straight course of the upper, and the sweeping curve of the lower, veins indicate an immense expanse of wing both in length and breadth; all the veins are exceedingly stout. The mediastinal vein is at first directed in a straight line toward (presumably) the middle of the costal margin, but at a distance of 20 mm. from the base bends very gently and very slightly downward, still continuing a nearly straight course, indicating the extension of the vein to the tip or nearly to the tip of the wing; at the extremity of the fragment, at about 40 mm. from the base, it lies midway between the marginal and scapular veins; but previous to this it lies nearer the latter. It lies in a slight depression, a little lower than the level of the interspaces beside it, as well as that of the marginal vein. The scapular vein, on the contrary, though broad and flattened like all the rest, lies at a high level from which the wing slopes in a rounded curve equally on both sides; it starts from the middle of the base of the wing, and following a course subparallel to the costal margin, especially beyond the extreme base of the latter, moves in a broad inconspicuous curve, apparently reaching the highest point of the curve at the extremity of the fragment. The externomedian vein crowds against the scapular at base and, at a distance of only about 15 mm. therefrom, it divides into two branches, the upper of which continues the course of the undivided base, but diverges very slightly from the scapular vein; so that at the end of the fragment the two veins are separated by scarcely more than the width of one of them. Like the scapular vein it lies at a high level, but the lower branch, on the contrary, falls rapidly beyond its origin, so as to lie, at the terminal portion of the fragment, at a lower level than the mediastinal vein; but unlike the mediastinal, and indeed all the other principal veins, it is weak, having less than one-fifth the width of the scapular vein; it diverges with tolerable rapidity from the main branch, and divides equally the space between it and the internomedian vein. The latter vein, again heavy, and also closely crowded at base against the veins above, as far as the division of the externomedian vein, sweeps downward in a pretty strong curve beyond this point, so that at the end of the fragment, up to which it is undivided, it is as far from the upper branch of the externomedian, as the scapular is from the mediastinal. It lies again at a higher level, the space between the lower branch of the externomedian and the internal forming a broad gentle arch, lower and less conspicuous than that between the mediastinal and lower externomedian veins, but otherwise similar to it, at the summit of which lies this vein. The anal vein is not crowded against those above it; it has a curve even more sweeping than, but running subparallel to, the internomedian vein, and emits several similarly curving branches, of which fragments of two can be seen upon the stone; at base it is separated from the veins above by a space several times its own width, and at the extreme base it seems to part more widely from them, and to have its root attachments at a considerable remove from them; the vein itself is neither depressed nor elevated.

The cross-veins of the wing are very conspicuous, especially in the two broad upper interspaces; here they are prominent, in relief, generally simple, occasionally forking, and then rather widely, generally curved or sinuous, subequidistant, and dividing the interspaces into cells generally about twice as broad as long. In the mediastino-scapular interspace they are generally regularly curved with the convexity outward; and the same is usually the case with the other cross-veins of the interspaces below, in all of which they are found (even in the slender interspace between the scapular and the upper branch of the externomedian vein); though here they are much feebler, more numerous, uniform and simple; they are especially feeble and numerous in the internomedio-anal interspace, as well as in the slight fragments that remain of the anal area.

Besides these cross-veins are a few others, the nature of which it is more difficult to divine: such are three short, curving, transverse impressions which cross continuously the base of scapular and externomedian veins; and also a considerable number of transverse impressions on these same veins away from the base generally crossing the vein, sometimes only half crossing it and usually in continuation of the ordinary cross-veins in the interspace below; these latter cross-veins are not shown in the figures; they are not conspicuous in the fossil and appear to be confined to these two veins.

In addition to these points it may be mentioned that the only fragment of a border which remains shows that the edge of the wing was spinous; toward the base the costal margin is furnished on its convex portion (pl. 17, fig. 11) with frequent short, oblique, spinous points, which further out seem to be altered to distant, recumbent, outward directed, longer and rather slender spines.

Length of the fragment 43 mm.; breadth 32 mm.; greatest width of upper interspace 10 mm.

This fragment is remarkable for representing the largest known insect-wing from the paleozoic rocks, not excepting the *Acridites formosus* of Goldenberg from Saarbrück, or my *Megathentomum pustulatum* from Illinois. Certainly not more, probably much less, than the fifth of the wing is preserved (pl. 17, fig. 12), but the direction of the veins, their very great robustness, and the extraordinary distance apart of the upper three, are clear indications that the spread of wing enjoyed by this insect was not less than 25 cm., and may have been even more than 35 cm., while the width could not have been far from 6 cm. All the principal veins are a millimeter or more thick.

The specimen occupies the entire surface of a reddish-brown iron-stone nodule and came from the coal measures near Chesterfield, between Shelton and Clayborne, Derbyshire, England; it was received for examination from Rev. P. B. Brodie, to whose collection it belongs. The reverse is in the British Museum, from which I have received excellent casts through

Dr. Henry Woodward. The specimen before me represents the upper surface of a left wing, or else the reverse of the lower surface of a right wing.

The exact position of a fragment as small (proportionally speaking) as this would seem to be indeterminable at first sight; and so indeed it would be, were there not other forms living at that time, belonging to a group from which this cannot be separated by anything in the structure of the base of the wing; and yet, as it differs strikingly from all of them in certain features, and from its immense size can be confounded with none, it merits distinct mention and a name. All of the principal veins are present, and from their trend and relative level, and from the width and nature of the interspaces, there can be no question that the insect belongs to the same group as the only other heretofore known neuropterous wings found in Great Britain, viz., *Corydalis Brongniarti* Mantell and *Lithomantis carbonarius* Woodward, and is only to be separated generically from them. Its proper position can therefore best be determined after the structure of those wings has been discussed,—a point to which we will now direct our attention.

Dr. Woodward is assuredly mistaken in referring Lithomantis to "the neighborhood of the Mantidæ," notwithstanding that he supports himself by the adherence to his views of such able entomologists as Messrs. Westwood, Waterhouse and M'Lachlan, who can hardly have made a serious study of the neuration. It bears indeed a vague resemblance to that of the Mantidæ, excepting in the hind wings, where the fullness of the anal area, with its special development of folding rays in the insect of to-day, need not be looked for in its less specialized ancestor; but when the elements of the neuration are examined, the resemblance is seen to be purely superficial. Then it appears that Lithomantis agrees with other ancient types, and not at all with the Mantidæ. The front wing of the Mantidæ has a very peculiar and characteristic neuration. The marginal vein forms the front border of the wing, as I believe it never does in any saltatorial Orthoptera, and always does in the Neuroptera. The mediastinal vein is simple, and runs in close proximity to the scapular, terminating near the tip of the wing. So far there is nothing essentially different from the condition of things in Lithomantis; but in the next three veins all is different. To use the specific example (*Blepharis domina* of Africa) given by Mr. Woodward: the scapular vein is perfectly simple as far as the extreme tip, when it divides into three very short nervules supporting the apical margin. In Lithomantis, however, it emits a stout inferior branch near the middle of the wing, which runs parallel or nearly parallel to the main vein, and probably (if it is like its allies of the time) sends off several branches to the lower apical margin. As this is one of the principal veins of the wing, differences which occur here are significant, and there is hardly any group of insects which has so unimportant a scapular vein as the Mantidæ. The differences are even more striking in the next two veins, better preserved in the fossil. In Blepharis (and it is much the same in all Mantidæ) the externomedian vein is divided at base into two main stems, the upper of which runs in close proximity to the scapular, and in the outer half of the wing sends downward three or four conspicuous oblique veins, which appear at first glance precisely as if they were offshoots of the scapular, which they are not at all; they only perform the office of such offshoots in other wings; the lower branch takes an irregularly longitudinal course below the upper branch, and emits similar veinlets to the lower margin; and the entire area occupied by the two branches of this vein and their offshoots covers very much the larger part of the wing. The internomedian vein, on the contrary, is exceedingly simple, being forked only once (often, in other Mantidæ, not at all), and occupies much less space than even the anal area. Now in Lithomantis the case is very different: the externomedian vein does not divide at all until near the middle, and then only once or twice, its branches covering an area which is certainly much less than a quarter part of the wing; while the internomedian vein subdivides numerously, no less than eight final nervures reaching the margin, and covering an area, certainly as great as, and apparently considerably greater than, that of the externomedian vein. These singular differences between the Mantidæ and Lithomantis, affecting the distribution of the three most important veins of the wing, leave no doubt whatever that the resemblances between the two are only superficial, and that Lithomantis can with no propriety be referred to the Mantidæ.

What place, then, should be assigned to Lithomantis? I believe we should compare it with certain other paleozoic wings, and notably with "*Corydalis Brongniarti*" of Mantell, to which indeed Woodward has himself compared it; speaking of their "marked similarity" and giving at the same time an original figure of this interesting fossil (reproduced in pl. 17, fig. 8).

The last insect, as I shall show, should be referred, neither to the modern genus Corydalis nor to Gryllacris, but is generically distinct from all modern types, and may bear the name of

Lithosialis Brongniarti.

Pl. 17, figs. 1, 2, 8, 9.

This insect is especially interesting from its being the first discovered in paleozoic rocks, and that at a time when, to use the words of Audouin, no fossil insect was known either from the lower oolite, the lias, the keuper, the muschelkalk, or the new red sandstone; still less in any older rocks. How astonishing then it must have been to find this trace in the coal! It was at first supposed to be a plant, and as such was sent by Mantell to Brongniart, with other remains from Shropshire. Brongniart placed it in Audouin's hands, and he drew attention to it on several occasions, — before the Entomological Society of France, the Academy of Sciences, and the Assembly of German Naturalists at Bonn, asserting its relationship to Neuroptera, where he placed it in the neighborhood of Hemerobius, Semblis, Mantispa, and especially of Corydalis. Mantell accordingly figured it in 1839, in his Medals of Creation under the name of Corydalis, adding in the second edition in 1844 the specific name Brongniarti. The figure given by Mantell (reproduced in pl. 17, fig. 9) is thoroughly bad, not one of the veins being correctly drawn, and giving an altogether false idea of the wing; that by Murchison, in the various editions of his "Siluria" (reproduced in pl. 17, fig. 2) is apparently made from the same drawing, and therefore almost equally bad: the anal veins alone are more correct.

No further notice appears to have been taken of this wing until, in 1874, Swinton, and again, in 1876, Woodward, gave us new illustrations of it, (cf. pl. 17, figs. 1 and 8) which leave little to be desired. Swinton thought he had discovered the relics of a stridulating organ at the base of the wing, and compared it to similar characteristics alleged to be present on the under surface of the front wing of the modern Gryllacris. He accordingly referred the wing to the Orthoptera, and even to the Locustarian genus Gryllacris. This view cannot possibly be maintained, and a more unfortunate comparison could hardly have been made. Swinton himself acknowledges that he could not succeed in finding a species of Gryllacris "with an effective file," and the semblance of one he figures cannot be ascribed to a stridulating apparatus; for (1) the "file" he figures could not produce any sound when brought into contact with a similar structure on the opposite wing, since from their course the two would not be brought into the proper relations to each other, or at least into such relations as they always are brought in stridulating Orthoptera; (2) but it could not be brought at all into contact with the similar part of the opposite wing, the wing-insertions being far apart in Gryllacris, and the supposed file lying at the extreme base of a vein in the middle of the wing; (3) if this were a stridulating organ, it would not only lie in a different area from that in which it lies in all other Locustarians, but would agree with its place in no other Orthoptera whatever.[1]

The supposed file in Gryllacris being no stridulating apparatus, any comparisons between it and the fossil from this point of view are of course misplaced; but, aside from this, the position and coarse of the supposed file of the fossil is entirely different from that of the supposed file in Gryllacris, more indeed as it really is in Locustarians. But a careful examination of casts of both obverse and reverse, kindly given me by Mr. Woodward, and which show even more details than are given either by Swinton or Woodward (as, for instance, the spiny nature of the edge of the costal margin), brings nothing to light which lends any support to this supposition.

In his comparison of the general neuration of the fossil wing and the modern Gryllacris, Mr. Swinton's language is vague; and his conclusion, though evident, is wholly erroneous. It needs only the figures upon his plate to point out the essential differences in the neuration. In the first place, a distinction of prime importance appears in the marginal vein, which forms the border (and is heavily spined) in the fossil, is widely removed from it in Gryllacris, the margin being formed of a film supported by superior offshoots from the marginal vein, which of course do not exist in the fossil. In Gryllacris, the scapular vein is crowded into a narrow space, embracing on the margin only the extreme tip of the wing; while no such contraction appears in the fossil, where the area embraced by this vein must cover the entire apical margin. The externomedian vein of the fossil is closely crowded against the scapular at base, and parts from it beyond with a sweeping curve (as in most Neuroptera), appearing as if a branch of it; while in Gryllacris it lies midway between the adjacent veins, and has scarcely the slightest downward tendency, its branches being equally parallel instead of divergent. The internomedian vein in the fossil is widely separated on either hand from the adjoining veins; while in Gryllacris it is equally crowded with the others. Finally, all the branches of the latter, as well as those of the preceding vein, impinge upon the apical margin in Gryllacris; while in the fossil they strike the lower border of the wing.

[1] Mr. R. Etheridge of the British Museum has examined the original specimen and "is convinced that not the slightest trace of any organ, as figured by Mr. Swinton . . . exists on the specimen in question. The supposed 'stridulating organ' is in fact only a fracture of the surface of the nodule in which the wing is preserved. This is shown both on the fossil and its counterpart." Geol. Mag. (2) VIII, 298, note.

These differences, many of which separate also most of the families of Orthoptera from those of Neuroptera, prove that the fossil is widely distinct from Gryllacris, which, on its side, has a neuration more nearly allied to that of Neuroptera than, perhaps, any other group of Orthoptera; any comparison with other Orthoptera would therefore be still more vain, the neuration of the fossil wing bearing so much closer resemblance to that of those groups to which Audouin at first referred it.

Compared even with Brodia, it will be seen that the essential features of the neuration are the same, with the single exception of the mediastinal vein, which in Brodia ends on the margin not far from the middle of the wing; while in this ancient "Corydalis" it extends no doubt nearly or quite to the tip. But exactly such a difference as this is found to-day between Raphidiidæ and Sialidæ, and there can be little doubt that all four of the wings which have now been discussed (comprising all the important fragments of wings from the English carboniferous rocks but one — a cockroach) belong to an ancient type of planipennian Neuroptera.

Of these, the two which are most nearly related to each other are, unquestionably, the *Corydalis Brongniarti* of Mantell and the *Lithomantis carbonarius* of Woodward. Indeed, the resemblance between them is so close that one would almost consider them as belonging to the same genus. The basal narrowness of the margino-mediastinal interspace, however, as well as the considerably greater importance of the internomedian area in Lithomantis, forbid this, though the course and general disposition of every principal vein is nearly identical.

Corydalis Brongniarti, then, being generically distinct from its synchronous allies, and widely different from living types, merits a distinctive name, and may be termed Lithosialis, to recall its relationship to the forms to which Audouin first compared it. From Lithomantis it differs in the points just mentioned; from Brodia in the basal breadth of the margino-mediastinal interspace, the much more numerous branching of the lower veins, and the greater extent of the mediastinal, besides the more uniform breadth of the whole wing; from Archæoptilus, in the proportionally narrow area occupied at the base of the wing by the upper two interspaces, and the far later division of the externomedian vein.

Objection would perhaps be made by some to the retention of Woodward's name of Lithomantis for an insect whose supposed resemblance to the Mantidæ is found to be erroneous, and which does not even fall within the suborder to which the Mantidæ belong; but, aside from the fact that it belonged to an age when the characteristic features of Orthoptera and Neuroptera were more or less blended, its outward aspect is at first glance by no means very different from the insect to which Woodward has compared it; and the retention of the name has an historic interest which should not be disregarded; the number of paleozoic insects is not, and is not likely to become, so great as to render the name itself an obstacle to a knowledge and easy recollection of its true affinities.

Attention may here be drawn to the apparent fact (there are many described fossils which I have not yet studied with sufficient attention to speak in any stronger terms) that while all the carboniferous Neuroptera of Great Britain belong to a single group, not only is this group not represented (at least at all conspicuously) in any other locality, whether in Europe or America; but also the prevailing forms of other coal measures, the Dictyoneuræ, Termites, etc., are entirely absent from England. It is a noticeable exception to the prevailing uniformity of insect type among carboniferous localities generally. The same exception does not exist among the arachnids and myriapods of Great Britain, as Mr. Woodward has shown in nearly all his papers upon fossil insects.

Concerning the other hexapod insects described from Great Britain we have here nothing to add besides a mere list of all the species hitherto recorded, with which this paper is concluded.

LIST OF THE CARBONIFEROUS HEXAPOD INSECTS OF GREAT BRITAIN.

Neuroptera.

1. **Lithosialis Brongniarti** Scudder, Geol. Mag., (2), viii, 297-300 (1881); — Ib., Harv. Univ. Bull., ii, 175 (1881).
   Corydalis (allied to) Audouin, Ann. Soc. Entom. France, ii, Bull., 7-8 (1833); — Murch., Wood Geol., ii, 680 (1839); — Murch., Silur. Syst., i, 104-105, fig. *a* on p. 105 (1839); — Ib., Siluria, p. 284, fig. 1 (1854).
   Sialidae (belongs to) Pictet, Traité Paléont., 2e ed., ii, 377-378, pl. 40, fig. 1 (1854).
   Corydalis Brongniarti Mantell, Med. Creat., ii, 575, 578, lign. 124, fig. 2 (1844); — Ib., ib., 2d ed., ii, 551, 554, lign. 181: 2 (1851); — Murch., Siluria, 3d ed., 320, foss. 81: 1 on p. 321 (1859); — Swint., Geol. Mag., (2), i, 3-5 (1874).
   Gryllacris (Corydalis) Brongniarti Swinton, Geol. Mag., (2) i, 5, pl. 11, fig. 3 (1874); — Woodw., Quart. Journ. Geol. Soc. Lond., xxxii, 60, pl. 9, fig. 2 (1876).
   Gryllacris Brongniarti Novak, Jahrb. geol. Reichsanst., xxx, 73-74, pl. 2, fig. 1 (1880).
   [Coalbrook Dale, Shropshire].
2. **Lithomantis carbonarius** Woodw. Quart. Journ. Geol. Soc. Lond., xxxii, 60-61, pl. 9, fig. 1 (1876); — Scudd., Geol. Mag., (2), viii, 296-300 (1881); — Ib., Harv. Univ. Bull., ii, 175 (1881).
   Archimantis (err. typ.) carbonarius Scudd., Mem. Bost. Soc. Nat. Hist., iii, 18, note 2 (1879); — Ib., Arch. Sc. Phys. Nat., (3) iii, 363 (1880). [Scotland].
3. **Archaeoptilus ingens** Scudd., Geol. Mag., (2) viii, 295, 300 (1881).
   [Near Chesterfield, between Shelton and Clay Lane, Derbyshire].
4. **Brodia priscotincta** Scudd., Geol. Mag., (2), viii, 293-295, 300, fig. on p. 293 (1881).
   [Tipton, Staffordshire].

Orthoptera.

5. **Etoblattina mantidioides** Scudd., Mem. Bost. Soc. Nat. Hist., iii, 72-73, fig. on p. 73, pl. 3, fig. 8, (1879); Ib., Geol. Mag. (2) viii, 300 (1881).
   Blatta sp. Kirkb., Geol. Mag., iv, 389, pl. 17, fig. 6 (1867).
   Blattidium mantidioides Goldenb., Faun. Saraep. Foss., ii, 20 (1877).
   An indeterminate fragment of another wing, perhaps of the same species, is mentioned and figured, fig. 7, by Kirkby as above. [Claxheugh, Durham.]
6. **Phasmidae** sp., Kirkb., Geol. Mag., iv, 389, pl. 17, fig. 8 (1867); — Scudd., Geol. Mag., (2) viii, 300 (1881). [Claxheugh, Durham.]

Coleoptera.

7. **Curculioides Ansticii** Buckl., Geol., ii, 76, pl. 46″, fig. 1 (1837); — Agass., Buckl., Geol., Expl. pl. 46″, pp. 1-2, pl. 46″, fig. 1 (1838); — Mant., Med. Creat., 2d ed., ii, 555 (1854); — Scudd., Geol. Mag., (2), viii, 300 (1881).
   Hesila Ansticii Gieb., Ins. Vorw., 143 (1856). [Coalbrook Dale, Shropshire].

The other species described by Buckland as a beetle has been shown to be an arachnid.

EXPLANATION OF PLATE XVII.

Fig. 1. *Lithosialis Brongniarti* $\frac{2}{1}$. The figure given by Swinton; copied from Geol. Mag., (2) I, pl. 14, fig. 3. The arrow points at the supposed file.

Fig. 2. *The same.* $\frac{1}{1}$. The figure given by Murchison; copied from his Siluria, 3d ed., p. 321. The figure given by Pictet is copied from the same.

Fig. 3. *Brodia priscotincta.* $\frac{2}{1}$. Showing simply the neuration with the heavier cross veins. Drawn by J. S. Kingsley.

Fig. 4. *The same.* $\frac{2}{1}$. Cross section of the same at the point where the dotted line is placed in fig. 3, to show the different planes at which the veins lie. Drawn by J. S. Kingsley.

Fig. 5. *The same.* $\frac{10}{1}$. A bit of the costal margin from near the tip of the wing, showing the double row of approximated depressed teeth. Drawn by J. S. Kingsley. The positions of figs 5 and 6 upon the plate would better have been reversed.

Fig. 6. *The same.* $\frac{10}{1}$. A bit of the same margin near the base, showing the single row of more distant and elevated teeth. Drawn by J. S. Kingsley.

Fig. 7. *The same.* $\frac{1}{1}$. The whole wing and stone. Drawn in color by J. H. Blake.

Fig. 8. *Lithosialis Brongniarti.* $\frac{1}{1}$. The figure given by Woodward; copied from the Quart. Journ. Geol. Soc. Lond., XXXII, pl. 9, fig. 2.

Fig. 9. *The same.* $\frac{1}{1}$. The figure given by Mantell; copied from his Medals of Creation, 1st. ed. II, p. 578.

Fig. 10. *Archaeoptilus ingens.* $\frac{1}{1}$. Cross section at the point where the dotted line is placed in fig. 11, to show the different planes at which the veins lie. Drawn by J. S. Kingsley.

Fig. 11. *The same.* $\frac{1}{1}$. Drawn by J. S. Kingsley.

Fig. 12. *The same.* $\frac{1}{1}$. Restored to its presumed size, etc. Drawn by S. H. Scudder.

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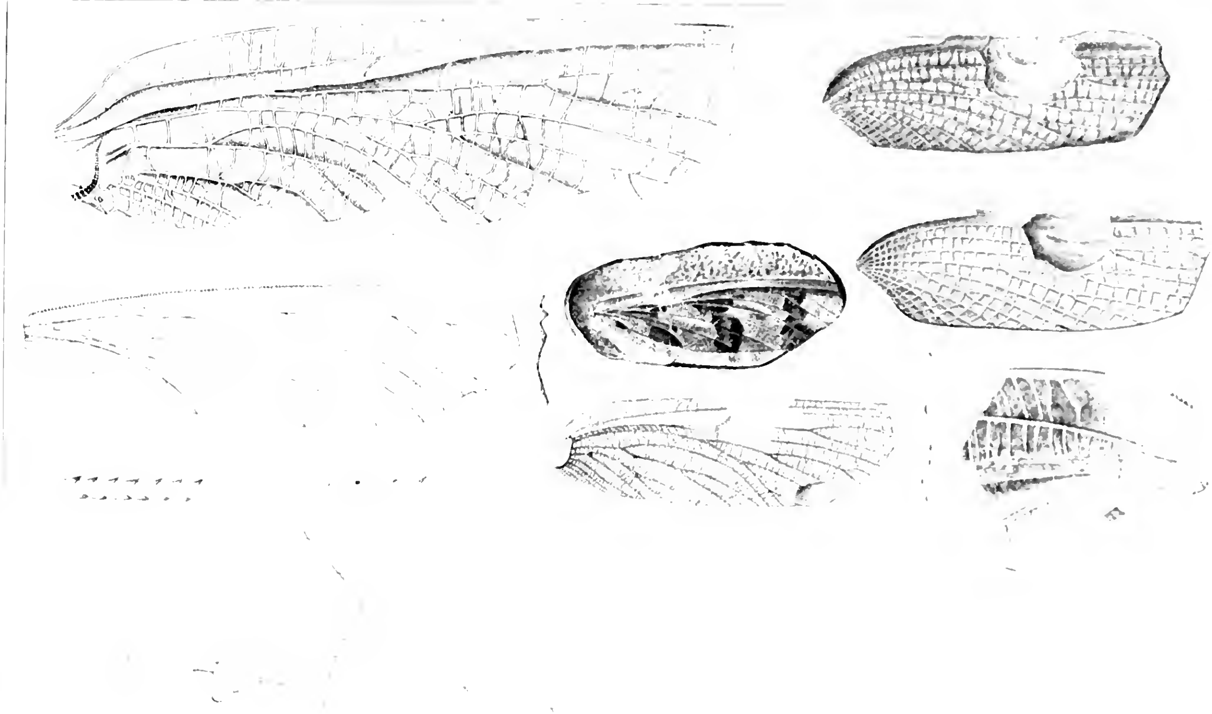

SCUDDER ON CARBONIFEROUS INSECTS OF GREAT BRITAIN

VIII. On the Development of Oecanthus niveus and its Parasite, Teleas.[1]

By Howard Ayers.

First Walker Prize Essay of the Society for 1883.

CONTENTS.

In this thesis I have endeavored to establish, among others, the following points.

FOR OECANTHUS.

1. The origin of the ovum in a germarium rather than from an ovarian epithelium.

2. The process of yolk formation by cell degeneration instead of secretion.

3. The occurrence of a primitive segmentation of the embryo before the appearance of the permanent segments.

4. The existence of a pair of appendages (some of them rudimentary) on each of the seventeen segments of the body.

5. The origin of the dorsal vessel as a paired organ, the lateral halves of which fuse and give rise to a median tube in the same manner as in some of the worms, and the origin of the blood corpuscles as nucleoli of endodermic cells.

6. The existence of embryonic gills.

7. The lack of any sharp distinction between a cell and its nucleus, and between a nucleus and its nucleolus.

8. The existence of segmental enlargements of the mesodermic somites, similar to those from which the nephridia of worms take their origin.

9. The origin and significance of the embryonic membranes among the Insecta.

10. The origin and significance of the dorsal organ among the Insecta.

FOR TELEAS.

11. The absence of embryonic membranes.

12. The occurrence of a larval form intermediate between the blastosphere and the cyclops larva of Ganin.

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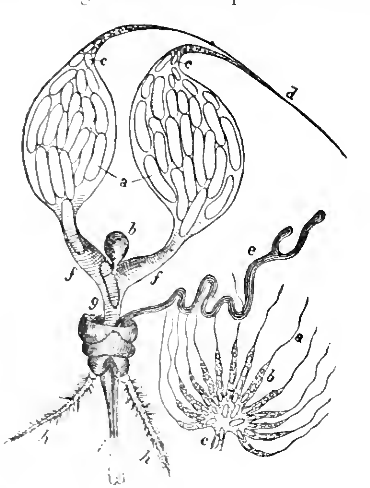
OECANTHUS NIVEUS.

The sexually mature ovaries of Oecanthus are bodies about the size and shape of an apple seed. They lie in the abdominal cavity above the alimentary canal, and on account of the mass of eggs contained in them completely fill, or even distend this cavity beyond its normal capacity. They are united anteriorly into a common terminal cord which is inserted in the wall of the dorsal vessel, in the thorax above the stomach. The origin and growth of this cord and of the ovaries is best seen in the embryo. From this point of insertion they are directed backwards, downwards and outwards, and terminate in the oviducts. They are held in place by connective tissue filaments, the peritoneal lining and the ramifying tracheal and nerve filaments.

The oviducts extend inward from their origin on the ovary and unite into a common duct, the vagina. At this point of union is given off the receptaculum seminis as a pouch from the wall of the vagina. At its posterior outlet the vagina is connected with the genital armature. Each ovary consists of from 10 to 20[1] delicate, thin-walled egg tubes or ovarioles covered by a net-like peritoneal membrane. This net is composed of cell-groups connected by narrower portions of the cellular membrane. These groups are composed of relatively large cells with finely granular, scarcely stainable protoplasm and a central deeply stainable nucleus. The ovarian tracheae ramify throughout this coating but do not connect with the tunica propria of the ovariole. This covering for the sexual organs is continuous with the peritoneum of the body cavity.



A. Fig. 1. B.

A. Female sexual organs. *a.* ovaries, *b.* recepta-[illegible] marks the beginning of the terminal filament; [illegible] terminal ligament; *e.* glandula appendicularis; [illegible] vagina; *h.* anal stylets; *i.* ovipositor. Magnified (from nature and after L. Dufour.)

B. [illegible] with the peritoneal and the connective-[illegible] removed and the ovarioles separated. *a.* ter-[illegible] (Endfaden); *b.* ovariole; *c.* oviduct.

C. Male sexual organs. *t.* almond-shaped testicle; [illegible] *v. s.* vesiculae seminales; *s.* anal stylets.

Each ovariole[2] consists of a double-walled, blind tube divided into two distinctly marked portions. The upper, filamentous part originates as a blind tube in the terminal cord of the ovary and extends with a gradual increase in size to the upper end of the lower or follicular part, which is funnel-shaped. The size of this terminal, filamentous portion or germarium, as I shall hereafter designate it, varies in cross-section from 12.5 μ to 5.6 μ. The follicular portion, or more properly speaking the vitellarium, begins with this funnel-shaped enlargement and extends to its insertion

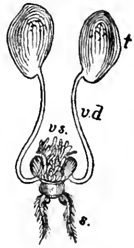


Fig. 1 C.

[1] According to [illegible] (28) they are 8–10 in number.

[2] Having doubts as to the truth of several points in the [illegible] by [illegible] (1), Brandt (9), Gegenbaur [illegible] (29). I wished to satisfy myself as to the structural details of the egg-producing and egg-maturing organ of insects. With this object in view I have studied with especial care the ovariole in Oecanthus niveus, Acheta abbreviata, Periplaneta sp., and Acridium sp. These four forms

into the oviduct. The tunica propria of the ovariole is a thin, elastic, structureless and colorless membrane, which in the vitellarium forms a tube whose diameter varies from .06 mm. to 1 mm.

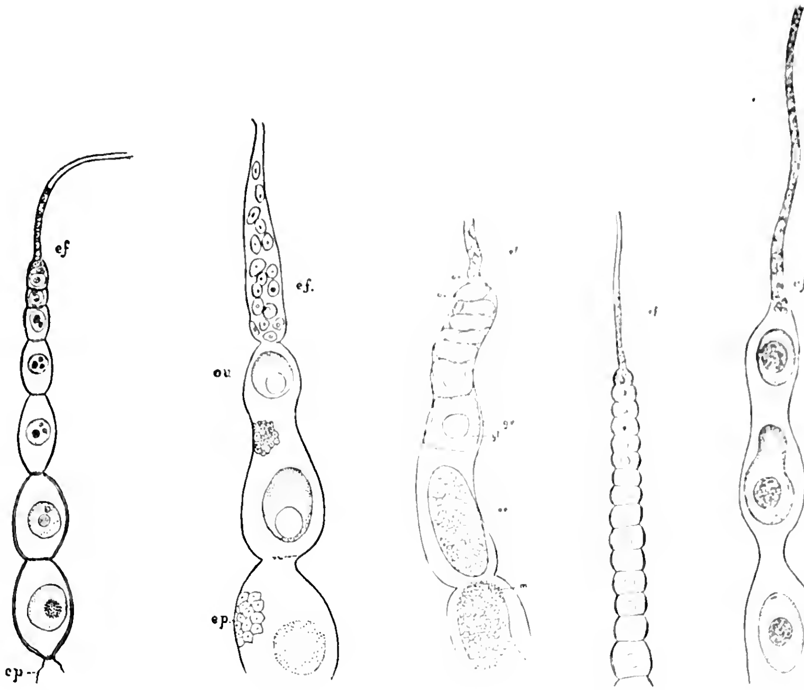


Fig. 2. Fig. 3. Fig. 4. Fig. 5. Fig. 6.

Figs. 2, 3 and 6. Ovarioles of Oecanthus. × 125. 2. dissected in sodium chloride solution; 3. from dissection in 0.1 per cent. chromic acid; 6. dissected in water.
Fig. 4. An ovariole of Acheta abbreviata, from a dissection in 0.1 per cent. osmic acid. × 125.
Fig. 5. An ovariole of Acridium sp. from a sodium chloride preparation. × 125.

The germarium [1] is filled more or less completely with cells of characteristic structure which, as sections show, have no definite relations to nor connections with the tunica propria; but, since there is no trace of an epithelial lining throughout the entire course of the germarium, these cells may in consequence lie in contact with the tunica.

Since the cells are of nearly the same diameter as the tube in its upper and middle portions they are generally disposed in a single row occupying the centre of the tube; they

possess egg tubes of the simplest type, where one would naturally seek for the primitive method of egg formation. The results of my observations differ in two essential particulars from the above mentioned theories, viz: in the *origin* of the egg and the *formation of the yolk*. The ovariole in these species varies only in histological details. The four forms represent three sharply defined families of the Orthoptera, and one of them is closely related to the oldest insects in geological time. For an exhaustive treatment of the origin of the germ and the formation of the egg, together with a review of the literature and a critical treatment of the theories held at different times on the origin and structure of the insect egg, the reader is referred to Brandt (9). For a general and comparative account of the origin of the egg throughout the animal kingdom one should consult Ludwig (29) and Balfour (1).

[1] See Bessels's (5) account of the origin and formation of ovarian germs in Lepidoptera, also Müller (34) and Claus (12).

may be flattened against one another but at all times a cell wall is to be distinguished. These cells have large nuclei with prominent nucleoli while the cell substance is found as an exceedingly thin layer covering the nucleus. The nuclear boundary is even more distinct than the cell boundary. Nuclei in the upper and middle part of the germarium seldom have more than one nucleolus and may be destitute of such a structure, while in the lower part and in the enlarged mouth two or three nucleoli are frequently found in each nucleus. These nuclei are amoeboid, their changes in form being most noticeable in the lower part of the germarium. In pl. 20, figs. 25, 26, 27, and pl. 21, fig. 25 are shown the structure and relations of the germ cells to the tunica propria. These germs pass down the tube into the upper end of the vitellarium where they become surrounded by a greatly increased amount of finely granular protoplasm that is in intimate contact with the epithelial lining of the vitellarium. (Pl. 20, figs. 1, 2, 3, 5, 27; pl. 21, figs. 28, 29, 30 and Figs. 2-6, on p. 229.) This epithelial lining, or follicular epithelium, is confined strictly to the vitellarium, in the upper part of which it is seen as a membrane one cell deep, either lining the walls of the tube or extending between and about the ova, thus separating them from each other and from the tunica. These epithelial cells are somewhat smaller than the germ cells found in the lower part of the germarium, and the relative amount of nuclear and cell substance is different in the two cases. The germ cells have a greater proportion of nuclear substance. The epithelial cells proliferate rapidly and soon increase the extent and thickness of the follicular membrane, which is at all times thinnest at its upper end, where it grows around the ovum in a thin sheet of small cells. In no case was a cell which from its size indicated its origin in the germarium found in process of division after reaching the vitellarium, whereas, in the germarium itself cells in such a condition are sometimes found. As the egg advances toward the oviducal end of the ovariole the wall of the epithelial follicle becomes thicker and more capacious from the increase in the number of cells composing it.

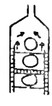


Fig. 7.

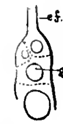


Fig. 8.

Fig. 7. Diagram of the formation of an egg follicle.

Fig. 8. An ovariole of Oecanthus from a dissection in distilled water. × 70.

The germinative vesicle, which is the transformed nucleus of the germ cell, becomes vesicular and at the same time acquires several nucleoli, which gradually enlarge but remain connected with each other and with the nuclear membrane by numerous tortuous filaments. Sometimes there is a single nucleolus and then the nuclear filaments are much more numerous. The nuclear fibres or threads are to be seen only aftert reatment with certain reagents (e. g. gold chloride, silver nitrate, osmic, chromic and acetic acids). The germinative vesicle is distinctly amoeboid in the upper follicles but shows this characteristic to a less degree in the two or three follicles before the one in which it disappears, while in the latter its amoeboid nature is again asserted. Its membrane is distinct until about the time of its disappearance, which occurs in the following manner. Near the time when the vitelline membrane is secreted, the wall of the germinative vesicle grows thinner.[1] It remains sharply marked off from

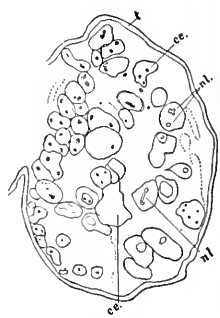


Fig. 8, a.

Fig. 8, a. Section passing transversely through an epithelial partition between two follicles. From an osmic acid preparation of an ovariole of Oecanthus. × 600.

[1] For a comparison of the different stages of this process in other animals see Bambeke (2), Van Beneden (3 and 4), Brandt (9).

the yolk but fades into the nuclear substance on the inner surface. The nucleolus and all other nodules of nuclear filaments or nuclear substance, extend themselves in the form of very delicate, tortuous threads which in the fresh condition give the vesicle a finely granular appearance. This process continues until the membrane has become so thin as to be indistinguishable in the fresh state. It finally disappears altogether, first at its upper, or sometimes at its outer, surface. (Pl. 20, fig. 1.)

Fig. 9. Fig. 10.

Fig. 9. An ovarian follicle of Oecanthus in which the germinative vesicle lies in contact with the surface of the follicular epithelium.

Fig. 10. Same as Fig. 9.

The germinative vesicle has in the meantime travelled from its central or subcentral position to the surface of the yolk and lies in contact with the follicular epithelium. The use of reagent causes a sharp line of demarkation between the yolk and the nuclear substance to appear in sections of the egg at this stage. This line of condensed protoplasmic substance appears to belong to the yolk. The nuclear substance gradually becomes diffuse in the region of this membrane but remains sharply marked off from the follicular epithelium. The entire nuclear mass now becomes a finely granular homogeneous cloud which spreads out over the surface of the yolk and in this manner disappears from view. (Pl. 20, figs. 28, 29.). At the t ime of the disappearance of the germinative vesicle the egg has acquired about one-half of its yolk substance. The latter is aggregated into an ovoid mass. The egg soon secretes about itself a membrane which at this time is to be detected only by treatment with hardening reagents.

The process of the formation of the yolk and the egg membranes (save the vitelline membrane) is a continuous phenomenon. By a process of nuclear proliferation, the follicular cells are elongated into a very thick columnar layer. (Pl. 20, figs. 1, 1, 13, 14, 18, 20. Pl. 21, figs. 24, 26.) These cells vary in their radial diameter with the number of nuclei present, and the latter vary from one to four in a single cell. The outer or first nucleus is sharply marked off from the small amount of cell protoplasm surrounding it, while each succeeding nucleus becomes less distinct, until the nuclear outlines are lost in a region of indifferent granular and filamentous substance, with here and there oil globules and bits of albuminous matter, distinct from the matrix of degenerated cell material out of which they have been differentiated by some chemical processes. In the upper follicles where the process is just begun the cells commonly possess two nuclei, and in the last follicle, or the one in which the chorion membranes are being formed, they also possess two, if at the beginning, but if at the end of the process, a single, small, degenerated nucleus, surrounded by a cell wall containing a proportionally large amount of a thin, watery protoplasm. In the follicles between these two extremes, where yolk formation is at its height, there may be as many as four nuclei in a cell, each surrounded by a proportionally small amount of finely granular protoplasm. The outer nucleus presents the characteristic appearance of a normally active structure, while the inner ones reproduce successively the characters of the degenerate nuclei of the last follicle. Finally, after the chorion is secreted and the egg has passed out into the oviduct, the remains of the follicular epithelium, together with the tunica propria, form a contracted mass,— the corpus luteum, — which disappears before the next egg makes its way into the oviduct. In pl. 20, figs. 11 – 17, are given surface views of the follicular epithelium in several successive stages of degeneration. Pl. 20, fig. 14 is from a follicle in which the yolk is being deposited; pl. 20, fig. 15, from a follicle in which this process is nearly completed; pl. 20, fig. 16, from a follicle where the chorion is being formed; pl. 20, fig. 17, from the corpus luteum. Fecundation probably takes place while the egg is passing into the vagina, since it is hardly possible that the male element could gain access to the follicles before the chorion is secreted.

The egg has acquired more than half its normal size before any membrane is to be distinguished surrounding it, consequently it is only in the lower follicles that the process of the formation of the membranes is to be observed. Before the pocket in which the egg lies becomes terminal, the vitelline membrane may be detected as a very delicate, colorless sheet surrounding the yolk. The most of the yolk material is already within this membrane, but from its subsequent increase in size it must be inferred that there are further additions to its mass by a process of endosmosis. Later there are deposited about this membrane two others, true chorion layers; both are derived from the same source as the yolk and by a process almost continuous with that which forms the latter. Both the vitelline membrane and the first layer of the chorion form continuous envelopes, but the second layer of chorion is interrupted at the upper end of the egg and in its place is deposited a micropylar apparatus. Although it is only a modified portion of the chorion and is at its outer and thinner edge in direct continuity with the outer chorion, this apparatus is easily separable as a distinct cap of thickened chitinous processes. The inner layer of chorion, which is deposited by the same cell mass as the outer layer, exhibits but faint indications of the subsequently deposited cap. During the deposition of the layers of the chorion the previously straight egg becomes curved, with its concave surface facing ventrad. This curvature fits the egg for the pit made by the ovipositor for its reception. By examining an infested stem these pits will be seen to be curved.[1] The egg having received its protective membranes is ready for deposition, and the epithelium of the terminal follicle, having now become much reduced in thickness by the production of these layers, forms but a loose sac around the egg. The latter on this account passes into the oviduct. On its passage through the vagina, the egg is coated by a mucous substance which hardens on exposure to the atmosphere or on contact with the pith of the stem in which it is laid. In the latter case it serves to retain the egg in position. The egg coatings, now five in number, may be arranged for convenience of reference as follows:

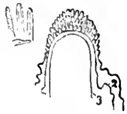


Fig. 11.
Micropylar cap, treated with caustic soda. The papillae of the cap are much elongated and the membranes swollen by the action of the reagent. × 10.
Three papillae further magnified are seen at one side of the figure.

1. Mucous coating—structureless—secreted by vaginal mucous glands.
2. Outer chorion—produced by the follicular epithelium—presents a series of surface markings or cracks.
3. Inner chorion—produced by the follicular epithelium—presents a series of surface markings or cracks less numerous and fainter than those of the outer chorion.

[1] In the allied Acheta abbreviata, the egg is not curved and is destitute of a micropylar cap. The eggs are laid in loose earth among the roots of grass. In Caloptenus spretus, according to Packard, the egg is curved and is provided with a micropylar end (?). The eggs are laid in ground which is rendered hard by sun-bake, so that the insect is compelled to drill special cavities for their reception.

4. Micropylar cap—produced by the follicular epithelium at the anterior end of the ovariole — possesses a very complicated structure.
5. Vitelline membrane — secreted by protoplasm of egg—structure similar to *zona radiata* of other animals.

From the above it is seen that the membranes are derived from three different sources— the egg itself, the follicular epithelium, and the vaginal mucous glands. The mucous coating is very thin when dry and is only to be detected on eggs treated with caustic soda or water; it is most abundant about the micropylar cap, frequently filling the spaces between the papillae.

The outer chorion is a dense, tough, homogeneous membrane marked with a series of parallel and cross surface cracks (Pl. 20, fig. 11, and Fig. 12, below) which are arranged with an extreme irregularity quite characteristic. The different systems of surface cracks cover limited areas and incline at various angles to each other. This arrangement of parallel and cross lines at varying angles of intersection reminds one of a city map in which the rectangular system of streets for each addition was laid out regardless of the direction in neighboring parts. The surface cracks, or grooves, in this layer vary in their depth, frequently extending nearly through the membrane. In the figure they should be represented by two parallel lines, since they are open spaces bordered on each side by the sharp edges of the membrane. The areas are sometimes perfect squares but usually when rectangular they are several times as long as they are broad. This layer tears with a sinuous outline across the cracks and solid membrane indifferently. Until near the time of the revolution of the embryo in the egg, this membrane is intact, and when the egg is ruptured it determines the course of the rupture of the other membranes. Just before revolution the outer layer is burst by the swelling of the egg and exposes the transparent inner layer. The relation of the cracks to the membrane, and of the membranes to each other and to the egg, is best shown in section. (Pl. 20, fig. 21.) This layer is deeply stained in safranine, haematoxylin and picro-carmine, but remains unstained in other dyes. Its thickness varies from 3.5 μ to 4 μ. On treatment with caustic soda it swells rapidly. At first small sac-like elevations appear over the surface of the egg; these gradually coalescing form a loose sac about the latter and remain united with it at the micropylar end where all the layers are more or less fused. During this swelling process the cracks disappear, the micropylar papillae enlarge, become transparent, and show a distinctly marked, central, curved lumen. If the action of the reagent is continued the inner chorion is affected in the manner described for the outer chorion, also coming away from the egg as a loose sac. Frequently one sees in this inner sac a mass of granular matter. The vitelline membrane does not swell in the alkali, but when brought in con-

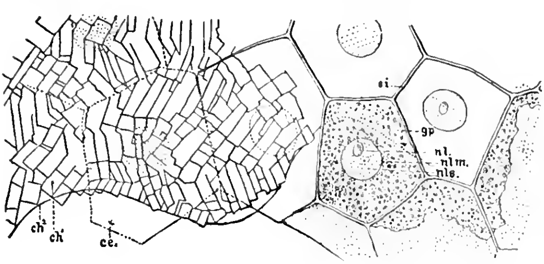


Fig. 12.

Surface view of the egg membranes and the serosa. From a chromic acid, glycerine preparation. × 400.

tact with it, quickly dissolves, exposing the egg contents. The folds or grooves of the inner chorion are never so numerous nor so large as those of the external layer. The inner membrane is much thinner than the outer one and quite transparent, so that by the use of caustic soda to remove the outer chorion one is able to make the otherwise opaque egg transparent enough for the study of the embryo in the fresh state. On removing the micropylar cap by means of caustic soda, there appear on the inner chorion beneath this cap polygonal areas with raised edges which fit into corresponding grooves in the inner surface of the cap. The inner chorion is more stainable than the outer, and is sometimes indented opposite the nuclei of the serosa.

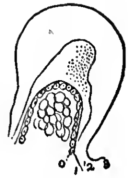


Fig. 13.

A living egg treated with caustic soda. The three egg membranes are separated from each other by the action of the reagent. 1.—Vitelline membrane. 2.—Second chorion. 3.—First or outer chorion. × 15.

The micropylar apparatus[1] belongs chiefly to the outer chorion and sometimes comes off with this layer when it ruptures. In the region of its fusion with the outer chorion it is composed of polygonal scales or areas, which gradually become more prominent as they approach the apex of the cone. From the upper angle of each area is given off a thickened protuberance or papilla into which the intermediate canal between two adjacent areas is continued as a distinct lumen. The papillae vary in shape from simple scale-like patches to nipple-shaped protuberances or even funnel-shaped enlargements, pl. 20, fig. 11. They are most perfect about one-third the distance from the apex toward the base of the cap. The apex itself is smooth or is furnished with only a few flat scales. Besides furnishing channels for the ingress of the male element, the micropylar cap serves as a thick, roughened plate, against which the insect may push when ovipositing without injury to the egg and without danger that the ovipositor slip from its place.

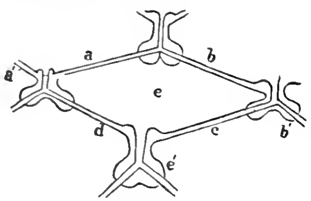


Fig. 16.

Diagrammatic sketch of a micropylar scale e and its thickened angles a', b'. The double lines a, b represent the edges of neighboring scales separated by a groove. × 600.

The vitelline membrane is of nearly the same thickness (4–5 μ) as the outer chorion and of a pale gray color. On surface view it appears finely punctate, while in optical section it presents a radiate structure entirely similar to the *zona radiata* of other animals. It is readily stained by any dye that stains cell substance. In the fresh egg it is at all times in close contact with the yolk, but in hardened eggs it does not shrink with the embryonic membranes and yolk, and hence is easily removed with the chorion.

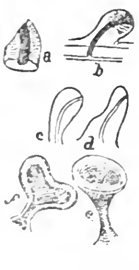


Fig. 14.

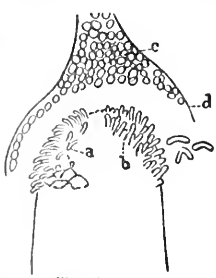


Fig. 15.

Fig. 14. a.—Fragment of a micropylar papilla showing its [illegible]. b.—[illegible] tip of another papilla. In this one the [illegible] extends to the vitelline membrane but does not pass beyond it. c, d, e and f.—papillae of different forms. × 600.

Fig. 15. The anterior end of an ovarian egg showing the manner of growth of the micropylar papillae. a and b.—[illegible] stages. c.—surface view of modified papillae [illegible] the lower edges of the cap. d.—tunica propria of the [illegible]. e.—[illegible] the upper portion of figure, erroneously marked c, remnant of the cell mass that secreted (?) the micropylar cap. × 50.

The yolk of the mature egg is composed of two distinct elements, fat bodies and albuminoid masses. The former are of nearly uniform size and are globular in shape. The surface of each sphere is differentiated into a thin pellicle, insolu-

[1] See Leuckart (27) for structure of micropyle and chorion among Insecta.

ble in ether, which surrounds a greenish-yellow fluid readily soluble in ether. The albuminoid bodies vary much in size and in their chemical composition. The latter is proved by the varying results obtained from the use of reagents. The superficial layers of many of them differ but little in their chemical composition from living protoplasm. But since they do not exhibit any of the physical properties of the latter, their substance must be considered as something different from protoplasm. The change of the fat into the albuminoid, and of the albuminoids into living protoplasm, is undoubtedly entirely effected by the chemical or assimilative action of the living protoplasm of the egg. When treated with osmic, acetic or chromic acid, the albuminoids are rendered vesicular. They stain deeply in picro-carmine and acetic-acid carmine, but not in safranine or alum-carmine.

In the ovarian egg after the disappearance of the germinative vesicle no traces of nuclei are to be found; but bordering certain of the yolk masses there are bands of stainable substance entirely similar to that which results from the degeneration of the follicular nuclei, except that it is confined to a definite and limited area encircling some of the yolk globules. (Pl. 21, figs. 23, 24.) After fecundation no trace of distinct cell elements was found until about the time of the appearance of the blastoderm. At this time the yolk masses lie in contact with the vitelline membrane and the blastoderm cells coming to the surface finally form a thin cellular layer between the yolk and the protective coats of the ovum. Eggs were taken from the last ovarian follicle, from the oviduct, and from elder stems where they had been deposited but a few (one to twenty-five) minutes; they were hardened in a HCl-alcohol preparation, removed from their protective membranes, stained in picro-carmine, sectioned, and mounted in balsam. In none of them were there found more traces of distinct nuclear elements than have been indicated above (pl. 21, fig. 23). The earliest stage in which *such* elements were to be distinguished showed a partially formed blastoderm, but from this time onward during the entire development of the embryo there are always numerous amoeboid cells to be found throughout the yolk. In pl. 21, fig. 31 is represented a section through an egg in this stage, treated in exactly the same manner as the earlier stages in which neither cells nor nuclei could be found. In pl. 21, fig. 17, and pl. 23, fig. 7, are seen five of these cells magnified 800 diameters, showing them to be both naked amoeboid nuclei and amoeboid cells. Pl. 21, fig. 31, shows the manner in which the cells help to form a blastoderm. The cell protoplasm extending out from one surface of the nucleus fuses with a similar plate from the neighboring cell. The nucleus extends into this projection and here its membrane is seen to be very thin. After these cells reach the surface of the yolk they furnish by rapid division a sufficient number of cells to form a membrane. (Fig. 17 and Fig. 12, p. 233, show the completely formed blastoderm.) The cells first arrive at the surface in the lower part of the egg in the region in which the embryo is to be found at a later period.[1] Only part of the amoeboid cells migrate to the surface. The others remain in

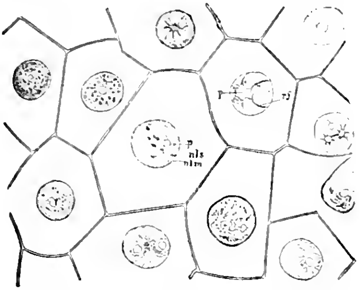


Fig. 17.

Surface view of fresh serosa from an Oecanthus treated with acetic carmine. × 500.

[1] Compare Brandt (10), Bobretzky (7), Weismann (41).

the yolk and at once begin to assimilate the yolk matter, changing it into cell protoplasm and nuclear substance. They increase rapidly by division in a manner similar to the blastoderm cells, but owing to their high degree of nuclear development they exhibit but a thin covering of protoplasm. The amoeboid processes[1] from each cell extend out among the yolk spheres and coalesce with neighboring pseudopodia, so that when the number of such cells becomes quite large there is fully formed an intricate network of protoplasmic filaments such as is partially indicated in Figs. 18–20. The nuclei apparently control this network and at times draw to themselves their pseudopodia, sending out new ones from other parts of the surface to unite with some other portions of the common network or to engulf and feed upon the yolk globules. When a free amoeboid cell comes in contact with a yolk globule, it folds or creeps over it and, in case the yolk body is large as compared with the cell, surrounds it by a thin layer of clear protoplasm, the nucleus of which bulges out from the side of the globule but still remains entirely surrounded by a thin layer of cell substance. In sections of hardened and stained eggs these amoeboid cells remind one of certain rhizopods that possess anastomosing filamentous pseudopodia extending in a radial manner from the entire surface of the central mass. In these amoeboid cells the fine threads of protoplasm are comparable with pseudopodia, and extend in all directions from the protoplasm which surrounds the central nucleus. The amoeboid cells which reach the periphery form a thin continuous cell layer of uniform thickness over the whole surface of the yolk,—the so-called blastoderm.[2]

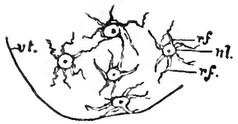


Fig. 18.

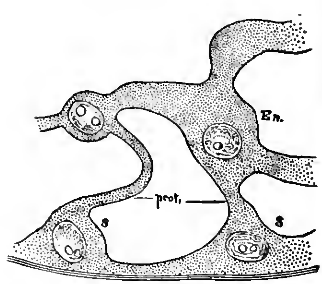


Fig. 19.

Fig. 18. Surface view of the serosa cells in an uninjured egg of Oecanthus. The protoplasm of the cells radiates from the central nucleus. × about 150.

Fig. 19. Optical section of the protoplasmic network in an egg of Oecanthus. × 300.

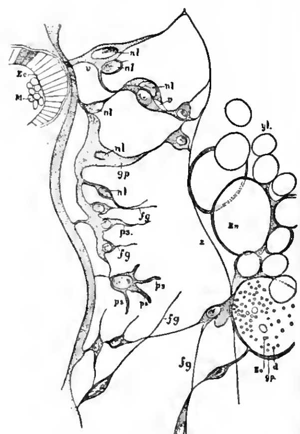


Fig. 20.

Surface view of the edge of the body wall a it is advancing over the yolk. From the embryo figured in pl. 19, fig. 1, in the region crossed by the line *b*. The space between the body wall and the line *z*, which limits the ventral extent of the yolk, is seen to be more or less covered with amoeboid cells connecting the yolk area with the edge of the body wall. The yolk mass lies underneath the entire field. × 800.

A tract of the blastoderm along the median line of the ventral (concave) side, lying nearest the deep or primitively head end of the egg, becomes thickened into a germinal band, which is the first trace of the *body* of the embryo. This thickening is caused by the proliferation and elongation of the flattened cells of the blastoderm in this region. On sections of this stage the germinal band is seen to be composed of a single layer of

[1] Compare Graber (22).

[2] The "Keimhautblastem" is entirely wanting.

cylindrical cells, each of which appears polygonal in surface view and has near its centre an oval coarsely granular nucleus. This plate of cells is about .7 mm in length (pl. 18, figs. 1, 2.) and protrudes beyond the surface of the surrounding blastoderm. The ventral surface of this germinal band is soon covered by a thin cell layer (amnion amt.). This layer makes its appearance at the edges of the band soon after it is formed, and gradually extends to the median line where its free margins coalesce. On account of the quantity of the yolk and the size of its masses, the details of its growth vary from the usual manner of formation. This variation is caused, as has been indicated, by the excessive amount of food-yolk, which takes the form of large enuclear masses which become reduced in size only by gradual assimilation within the amoeboid cells. While the germinal band is still a single layer of cells the rest of the blastoderm, at its line of union with the band, pushes up from its edge in the form of a fold; but as the space between the germinal band and the vitelline membrane is too narrow to allow the ingrowth of this fold in its primitive condition, the lower or amniotic layer is retarded in its growth toward the middle line and only assumes the nature of an embryonic membrane some time after the edges of the upper layer (or serosa) have united, and all traces of its manner of formation have disappeared (pl. 23, fig. 8). The cells which form the amnion are given off from the lateral edges of the germinal band, and even after the fusion of the free margins in the median line this membrane lies closely pressed upon its surface until the appendages by their outward growth push it off. The cells of the amnion finally assume the same polygonal form as the serosa cells, (pl. 18, figs. 4 and 10,) but remain throughout their existence much smaller than the latter. In sections of the germinal band at this stage there is seen to be an irregular, but usually continuous, layer of cells (mesoderm) lying immediately beneath the cylindrical cells (ectoderm) of the band. Lying at short intervals from one another are seen large amoeboid cells apposed to, or fused with, this layer of smaller mesodermic cells. These bodies or yolk cells, which have come to the surface from the central yolk mass, are five or six times as large as the mesodermic cells and appear to be in process of division. They doubtless give rise to the smaller mesodermic elements. The latter are closely apposed to the under surface of the germinal band and so flattened that their long axes are parallel to the surface of the band.

I am at present unable to affirm or deny the existence of the invagination[1] which in most insects leads to the formation of these mesodermic elements, for, although most of the facts relating to this mesodermic invagination seem to point to the conclusion that it is wanting altogether, there are in some sections structural details indicating the possibility of its occurrence in a modified form. The evidence against its occurrence in Oecanthus is as follows: In sections of the egg in which the serosa is continuous over the germinal band, and the amnion is present only in the form of a few flattened cells pressed closely against the outer edges of the band, the mesodermic elements are seen in respective sections to form either an unbroken line of small cells across the band, or two lines of cells, one on each side the point at which the invagination would occur. In some cases only two, three or four cells occur at irregular intervals in the extent of the section. Here and there the large yolk cells are fused with the under surface of the germinal band; in some cases they are apparently breaking up into cells of the size and appearance of the

[1] Compare Tichomiroff (40).

mesodermic elements. Furthermore, in this stage all the cells of the germinal band are provided with a single nucleus, and no trace of cell proliferation is seen in any part. As favoring the existence of an invagination it may be observed, that some of the sections show an arrangement of the cells which indicates a disturbance in their primitive position. In pl. 22, fig. 28, is shown this disturbed arrangement. The outer ends of the cells on either side the median line incline toward the latter. This arrangement of the cells is similar to that found in sections of eggs of other insects just before and after the invagination has taken place. Moreover, the cells of this median region appear to be less regularly columnar than those on either side. By far the greater portion of the mesodermic elements, however, originate from yolk cells which migrate to the region of the germinal band and there undergo division.

The mesoderm has formed a continuous sheet over the inner side of the germinal band before any modification in the form of the embryo appears. The almond-shaped thickening is soon divided into two tolerably well marked regions by the enlargement of the head end. The narrower portion of the germinal band increases somewhat in length and the abdominal end becomes more broadly rounded, so that the embryo presents the appearance shown in pl. 18, fig. 3. The mass of yolk substance during this time has undergone important changes, due to the greatly increased number of yolk cells, which are to be seen at this stage as grayish masses, larger than the yellow yolk globules and about the size of the albuminoid masses. These occur at irregular intervals and by their transparency help to clear up the yolk. The oil globules have decreased in number and size, while there has been a proportional increase in the number and size of the albuminoid bodies.

With the further growth of the embryo the head lobes increase rapidly in breadth, the ectoderm at the lateral edges becomes thicker, and the posterior portion of the embryo becomes spatulate in form with the enlarged part of the spatula forming the tip. There appears a depression in the middle of the forehead which helps to make more conspicuous the bilateral symmetry of the head region. It indicates the position of the future labrum and forms the inner boundaries of the two cephalic ganglia, which are developed on either side of this depression at a much later stage. Almost simultaneously with the appearance of this depression, two lateral folds are formed in the spatulate portion of the embryo (pl. 18, fig. 4), which, besides emphasizing the bilateral symmetry of this part, serve respectively to mark off the maxillary and thoracic regions, thus leaving the abdominal region conspicuous from the absence of any such differentiation of its surface. The general shape of the folds may be compared to a figure made up of the Arabic numeral 3 for the right fold and the same figure reversed for the left fold. The anterior portions of both folds are thicker and approach each other closer than the posterior portions. The folds are thickest and most sharply defined in the maxillary region. At their origin, apparently within the bounds of the head folds, they arise sharply from the general surface of the embryo, gradually increasing in breadth until near the middle of their length, and then as gradually decrease until they pass into the thoracic folds. The latter are of the same breadth throughout their extent and fade insensibly into the surface of the abdominal region.

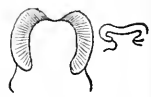


Fig. 21. a.

Fig. 21. Outline of the head region of a young embryo. The extent of the head folds is distinctly marked. × 50.

a. Outline of a transverse section of the head at this stage. ×50.

At this stage the amnion forms a complete covering over the surface of the embryo. The thickened outer edges of the head fold are at this time continuous behind with the outer edges of the germinal band, but they gradually grow in towards the median line (pl. 18, fig. 5), and are at the same time bent forward towards the region of the future mouth. The rounded angle made by the posterior end of the head fold is the first indication of appendages (the antennae). The anterior ends of the maxillary folds fuse and, owing to the proportionately more rapid growth of the thoracic-abdominal than of the cephalic region, the connecting portion of these folds lies posterior to the antennae and forms a transverse elevation extending entirely across the embryo behind the cephalic region, forming the anterior limit of the maxillary region. It will be noticed that it is an unpaired structure. In the stage represented in pl. 18, fig. 5, the maxillary and thoracic constrictions have become more sharply defined, since the folds have travelled to, and now form the edges of, the embryo, but the strictly abdominal region has not kept pace in its growth with the anterior regions. The embryo is now composed of four well marked regions: cephalic, maxillary, thoracic and abdominal.

The cross fold between the cephalic and maxillary regions grows fainter in the median line, and there are gradually raised from the surface five pairs of protuberances (pl. 18, figs. 8 and 9). These ten prominences which arise within the region of the maxillary and thoracic folds appear simultaneously. The forces producing them also cause a general elevation of the lateral walls of the body above the surface of the germinal band. By the elongation of the embryo that now takes place a space is left between the antennal folds and the first pair of maxillary appendages, the floor of which is at first perfectly level, but somewhat later is pushed up in the manner described for the five succeeding pairs. The prominences arising in this space are first sharply defined on their posterior borders. Whether this pair of prominences arises within the area marked off by the anterior maxillary fold is still uncertain. At least they arise very close to, if not out of, the fold itself. With its disappearance, the lateral thickenings of the maxillary and thoracic regions become marked into segments by the appearance of four pairs of marginal notches, so that the maxillary region is divided into two, and the thoracic into three, sharply marked segments. These notches extend themselves across the embryo in the form of shallow furrows meeting in the median line. Later the abdominal region becomes segmented in the same manner but the notches are never so distinct as in the anterior portion of the embryo.

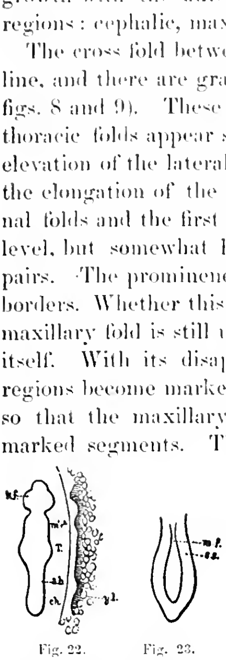


Fig. 22. Fig. 23.

Fig. 22. Ventral and side views of an abnormally shaped embryo. × 40.

Fig. 23. Abdominal region of an embryo of the same degree of development as the one shown in pl. 18, fig. 11. × 25.

The abdominal region has now increased in length until it is nearly as long as the rest of the embryo; its posterior part is broadened into a caudal enlargement, while its very tip is produced into a small papilla. The head region meantime undergoes marked changes, for there occurs an invagination of the lateral ectodermic wall in front of the basal end of the antennal fold. In this manner the limits of the antennal and brain regions are sharply defined. While this invagination is progressing the lateral edge of the ectoderm in front of it becomes differentiated into a superficial, limited, crescentic thickening and a deeper continuous layer.

The folds which project inward from the antennal region at length extend far forward and unite in the median line, thus bounding a V-shaped area the apex of which is near the front end of the embryo. Near the angle of this depressed area there appears a shallow, cup-like cavity,—the beginning of the stomodaeum.

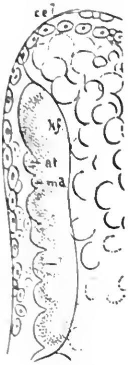


Fig. 24.
A lateral view ... [illegible] ... the ... certain ... of a ... nature ... seen at the ... of the egg; ... structure ... distinguishable with ... × 50.

The mandibles are now seen as definite oval prominences, while the five pairs of appendages posterior to them appear in optical cross-section to be composed of two concentric circles of cells. This appearance is produced by the two apposed cell layers, ectoderm and mesoderm. The appendages grow out perpendicularly to the germinal band, but later are deflected towards the abdominal region until they finally come to lie in a plane parallel with the longitudinal axis of the body. At an early stage they are sometimes to be seen slightly bent toward the head (pl. 18, fig. 9). As the appendages grow out, the egg begins to increase in volume and the cracks in the chorion grow less distinct. Soon after the mesoderm has extended into the hollow appendages, there appear successively a varying number of abdominal protuberances exactly similar to the maxillary and thoracic appendages in their earliest stage of growth. Of these only two pairs ever reach any considerable degree of development, they are the first and the last abdominal. The former grows to the length of the mature mandibles and then atrophies. It varies in shape from a finger-like process (pl. 18, fig. 17) to a lobed outgrowth, and in the later stages is covered by the last thoracic appendage. The last abdominal appendage is the primitive anal stylet and acquires a very complex structure which will be described in connection with the hatched insect.[1] The intermediate prominences never pass beyond the simple knob-like stage. The mesoderm extends into all of them as an inner layer apposed to the ectoderm, such as has been described for the maxillary and thoracic appendages.

About the time of the beginning of the invagination for the stomodaeum, there may be detected both in fresh and in hardened embryos a more or less sharply defined linear depression (the Primitivfurche of Hatschek), extending the entire length of the embryo. It is most distinct in the maxillary and thoracic regions and grows gradually fainter as it advances toward the tip of the abdomen just before reaching which it bifurcates, and the resulting lines, after extending for a short distance along the region of the caudal enlargement, approach each other and by their coalescence surround a pear-shaped, depressed area. This line first appears in the thoracic region and grows both ways. It ends in front just behind the mouth opening, while its posterior cup-like termination indicates the position of the future proctodaeum. The line itself is the superficial indication of a longitudinal invagination to form the nervous system. The evidences of this invagination, which appears thus early in the development of the embryo, persist for a considerable time.

The upper lip appears simultaneously with the invagination for the stomodaeum and arises as a flap or fold in the median line between the bases of the antennae, from the

[1] Compare this embryonic stage with the active larva of Lepyrus fasciata, a Neuropteron which has all the segments of the body provided with articulated appendages.

region where the antennal folds united. It projects backward and downward so as to partly cover the mouth opening. The caudal enlargement is now greatly changed in its relation to the embryo. It has up to this time been lying in the same plane with the body of the embryo, but by some means at present unknown it is reflected toward the head, so that its dorsal side is uppermost and the ventral surface of the last 3–5 segments of the abdomen lie in contact with the ventral surface of the preceding segments. It forms in this stage a ⊆-shaped fold.

The amnion is now seen springing, not from the tip of the abdomen, but from the region of the last pair of abdominal appendages, the anal stylets; in other words, the posterior end of the abdomen has grown backward beyond the limits of the amniotic membrane and lies free in the yolk. Since the force which causes the folding seems to act through the amniotic layer, it is apparent that this free abdominal tip will not be changed in direction but will be merely drawn forward and displaced to a plane ventral to the body of the embryo, with which it remains parallel. The pear-shaped depression in which the nervous invagination of the median line terminates behind has, by gradually deepening, extended back to the tip of the abdomen, and it is the blind end of this pocket which forms the tip of the last ⊂ of the ⊒. (See pl. 18, figs. 19, 20, 21, 22, 29; pl. 22, figs. 18–21 and 26.

The intimate connection of this pocket, or proctodaeum, with the invagination that forms the nervous system is worthy of notice. Compare Ganin (19, pl. XXXI, figs. 6, 9, 10-12, Platygaster).

After sprouting out from the body the appendages grow rapidly and soon show constrictions near their bases. In the case of the mandibles and maxillae the free ends also become lobed. (Pl. 18, figs. 20–22.) The three oral appendages are trilobed; the lobation is most prominent in the second maxillary and least in the mandibular appendage. The primitive appendage is first divided into two lobes and the inner of these becomes secondarily divided into two. The antennae and thoracic appendages grow with equal rapidity until the time of revolution, when the antennae suddenly commence an extremely rapid growth and soon acquire a length equal to twice that of the body. During this rapid growth there is a gradual decrease in the diameter of the appendage, and constrictions appear in its walls at irregular intervals. The upper lip is now a broadly ovate flap and entirely conceals the mouth opening. The first pair of abdominal appendages has reached its maximum development (pl. 18, figs. 22 and 23), whereas the last abdominal pair is scarcely more advanced than the nine intermediate rudimentary appendages, which are now prominent elevations of the body wall and show the mesodermic or inner layer and a central lumen, when seen in optical section.

The stomodaeum has so far advanced as to project some distance beyond the inner wall of the body, its blind end lying free in the yolk. It is a circular tube with a distinct lumen extending from the mouth opening to the blind end. Its wall is composed of cylindrical epithelial cells. The proctodaeum has grown but little in length, and, like the stomodaeum, its free blind end extends into the yolk, while its lumen communicates by means of the anal opening with the amniotic cavity. Its anal end is bordered on either side by the enlarging anal stylets.

In cross sections of embryos of the stage represented in pl 18, fig. 17, the median line seen on the ventral surface of the embryo is shown to be the outer ends of cells whose nuclei have migrated to the dorsal ends of the cells (pl. 23, figs. 9-12), while the walls of their ventral ends have been so compressed as to produce in this manner the peculiar fibrous structure of the ventral portion of the invaginated area. (Compare Hatschek, 23, Taf. II. fig. 2.) There are differentiated on either side of this central, invaginated portion two limited tracts of cells within the ectodermal layer, which ultimately go to form a part of the nervous system. These two tracts have been designated Seitenstränge by Hatschek. These "lateral cords" are composed of large cells with scarcely distinguishable cell walls, which enclose large spherical nuclei containing from one to five nucleoli and their systems of radiating nucleolar fibres and granules. The nucleolus is usually angular or bar-shaped and eccentric in position. The nuclei of these ganglionic cells are from three to five times the diameter of the nuclei of the ordinary ectoderm cells.

The structural conditions to be seen in sections have been described, in the case of the earliest stages of the germinal band, in connection with the account of the origin of the mesoderm. I have not been able to trace the origin of the lateral cords of the nervous system back to such a definite tract of cells as Hatschek has in his studies on Bombyx chrysorrhoea. On the contrary, in sections of the germinal band before the appearance of the median invagination there are to be seen, in the region of the future side cords, two lateral grooves. The cells in these regions have the characters of the cells invaginated for the middle cord and they thus indicate the origin of the two lateral cords as invaginations of the superficial ectoderm, and not as linear tracts of cells budded off from the inner ends of the epithelial cells of the germinal band, as Hatschek has figured and described for Lepidoptera (loc. cit., pl. I, fig. 6, p. 8). The sections of the stages in which these cells assume their characteristic appearances show them occupying the region of the future lateral cords, but not confined within such definitely marked areas as Hatschek figures. Before the appearance of the appendages the mesoderm is seen to lie as a continuous, thick layer of cells apposed to the germinal band. This condition persists in the abdominal region after the thoracic appendages have grown out, but disappears before the invagination for the nervous system has extended itself into this region. (Pl. 22, figs. 27 and 28.) It divides into two lateral plates as the invagination advances. In their outer halves these lateral plates of mesoderm are split into two sheets which contain between them the primitive body cavity (pl. 23, fig. 13,l and figs. 11 and 12, bc), but the latter soon disappears by the fusion of its walls. The separation of the splanchnic and somatic layers of the mesoderm occurs before the invagination for the middle cord, but after the formation of the lateral cords of the nervous system. The primitive body cavity exists in the form of a pair of tubes extending from the head region backward for a greater or less distance; but on account of the retardation in the development of the abdominal mesodermic plates, the body cavity of the thoracic region has been changed by the process of segmentation into a number of closed sacs[1] before the cavity has appeared in the abdominal region. The body cavities of the opposite sides do not communicate, although the mesodermic plates have not been divided in the median line. Subsequently the mesoderm occupies the lateral region of the germinal band and is entirely lacking in the region of the middle cord. After the

[1] The posterior wall of each sac is continued backward for a short distance in the form of a short pocket, reminding one of the enlargements in the splanchnic half of the posterior wall of the mesodermic segments of worms. The fate of these pockets is not yet known.

completion of the nervous invagination the mesoderm again unites in the middle line, and later becomes separated into its permanent somatic and splanchnic layers.

The cavities of the cup-like pockets of mesoderm extending into the appendages are at first in direct communication with the yolk cavity, but they soon become cut off from the main cavity by cross partitions of mesoderm which close the opening by an annular constriction. (Pl. 18, figs. 17, 20, 21, 24; pl. 22, figs. 23-25; pl. 23, figs. 11, 12, 13.) The mesodermic lining of the antennae and upper lip is entirely similar to that of the other appendages. In the case of the upper lip, however, the formation of the ingrowth is somewhat different: the mesodermic sheet is pushed off from the ectoderm by the ingrowing stomodaeum (pl. 23, fig. 13) and, as the latter extends inward taking a longitudinal direction, the mesoderm grows around it from its dorsal side, the two mesodermic folds coalescing in the median ventral line; from this portion of the mesodermic layer the lining of the cavity of the upper lip is derived. In the head region the ectoderm is thrown into folds by the proliferation of the cells of certain tracts. These thickened tracts give rise to the cellular mass of the supra-oesophageal ganglia.

The fibrous portion of the brain as well as that of the ventral cord is undoubtedly furnished by the cell walls of the ganglionic cells (pl. 22, fig. 2). In pl. 18, fig. 24, are shown the internal ectodermic folds of one side of the head, *o*, being the lumen or cavity of the head from which the mesodermic elements have receded; *fd*[1], the lower fold lying against the invagination *sk*. of pl. 18, fig. 15; *fd*[2], the upper, outer fold which, to judge from its size, probably gives rise to most of the brain mass. Contrary to the observations of Hatschek (23, pp. 9, 10), I find the mesoderm extending into the head region, where it is also provided with a body cavity (pl. 23, fig. 13.1). In pl. 22, figs. 18, 19, 20, 21, 22, are shown sections through the end of the abdomen and the proctodaeum of an embryo of about the stage outlined in pl. 18, fig. 21. The proctodaeum projected beyond the end of the dorsal ⊐ of the S, and consequently the first few sections pass through the proctodaeum alone. In figs. 18 and 19, pl. 22, the mesoderm is seen as a crescentic layer only partly surrounding the thick ectodermal wall of the proctodaeum on its dorsal side, whereas, a little farther from the end (fig. 20) it has nearly enclosed it. In fig. 21, the region of the free end having been passed, the amnion is seen in section extending over the anal stylets, while the mesoderm is confined to the ventral surface of the germinal band. In the case of the proctodaeum, as was also seen in that of the stomodaeum, the mesoderm grows around the invaginated mass from the dorsal side and its limbs coalesce in the median ventral line. Sections through the maxillary region at this stage (pl. 22, fig. 23) show the first maxilla to be a three-lobed, much broadened appendage.

For convenience of description, I will first give a sketch of the development of the embryo during the third stage as a preliminary to the more detailed account of the development of the organs. The general relations of the embryo to its membranes and to the yolk mass at the close of the second stage may be briefly stated as follows. The egg has increased much in volume and the outer chorion has ruptured, exposing the inner layer. The embryo extends along the concave side of the egg for two-thirds of its length, with its abdominal end folded upon itself in a S fold, from the ventral arm of which the amnion extends over the ventral surface of the embryo as an entire sheet, united with the embryo along its lateral margins and the dorsal edges of the head fold (pl. 20, figs. 7 and 8). On the concave side of the egg this amnion intervenes between the ventral, or outer, surface of the embryo and the serosa, while on the other side the yolk intervenes between the deep, or dorsal surface and the serosa. The amnion and serosa are not united at any point, but may lie in contact. The stomodaeum and proctodaeum extend into the yolk, but end blindly. The embryo is a closed sac, as it has been since the union of the two lateral folds of the amnion. The serosa now fuses with the amnion lying over the region of the forehead, but the two layers remain separated for the remainder of their extent.

The resulting membrane becomes first very thin and finally ruptures, so that the amniotic cavity communicates freely with the space between the vitelline membrane and the serosa, but does *not* open into the serosal cavity, neither does the latter open into the vitelline cavity. (Compare Brandt, S. Calopteryx. Hemiptera parasita.) By the contraction of the internuclear protoplasm of the serosa (this process may possibly be aided by the exertions of the embryo itself, since at this time traces of muscular fibres have made their appearance) its cells, which at first form only a single layer, are greatly changed in their mutual relations, and the serosal sac is changed into a bag, the walls of which are greatly thickened and furnished with an opening at the end where the fusion with the amnion has taken place. This is the earliest stage in which I have observed the external opening of the yolk sac. In the meantime, the embryo has (pl. 20, figs. 8 and 9) partly everted itself through the opening, and the serosa is thickened at the apex of the egg. The shortening of the serosa consequent upon the contraction of its cells is the mechanical force which, applied to the inner surface of the embryo through the yolk mass, causes its eversion through the ruptured wall. The upper lip protrudes first and is soon followed by the head, antennae, and maxillae. The embryo now lies curved across the lower blunt end of the egg with one-half of its body uncovered by the amnion; the other half still lies within that membrane and retains its terminal flexure (pl. 20, fig. 9). The head now moves upward on the opposite, or convex, side of the egg and the embryo again assumes a position parallel to the long axis of the latter. But compared with its first position the embryo lies on the opposite side of the egg and faces in the opposite direction. The abdomen is now straightened out and the proctodaeum projects into the yolk, which has in the meantime partly descended into the cavity between the ventral and dorsal walls of the embryo.

At this time the ventral portion of the embryo is composed of three layers: ectoderm, mesoderm, and endoderm. (Pl. 22, fig. 1.) The ectoderm of the ventral side is highly differentiated. From it have arisen, in addition to the ventral wall of the body and its appendages, the nervous system, and the epithelial lining of the fore and hind gut. It gradually becomes less complex toward the dorsum, where it is an exceedingly thin cellular membrane in the condition of a syncytium. The mesoderm extends as a more or less complete layer over the inner surface of the germinal band into the pleural, and later into the dorsal, region. The endoderm, as a distinct layer, is limited to a sac-like sheet extending over the ventral surface as far posteriorly as the blind end of the proctodaeum, over which it folds and is finally lost in the yolk. Anteriorly it curves around the stomodaeum and is continuous with the yolk-sac, which still projects beyond the body walls. The completed dorsal wall is first formed in the region of the proctodaeum, and from that point the closure gradually extends forward until the wall encloses the constantly decreasing yolk-sac.

The heart is formed in connection with the coalescence of the mesodermic plates in the median dorsal line and is to be detected as a distinct thin-walled tube opposite to, or slightly in advance of, the anterior edge of the thickened ectodermic layer. It is formed in the head region only after the yolk-sac has passed entirely within the body. When the heart is partly formed, the mesodermic plates anterior to their point of union form in the living embryo two pulsating membranes which, to judge from Dohrn's (15) observations on Gryllotalpa, differ in their formation from the homologous membranes in the latter insect. I have not observed pulsations in the dorsal mesodermic layer after union of the two plates, such as Dohrn has described for Gryllotalpa; but before the coalescence takes place the free edges of the lateral plates are thrown into wave-like motion at each pulsation of the formed portion of the dorsal vessel. The pulsations originate from the contractions of the segmental muscles in the posterior abdominal region, which drive the corpuscular fluid forward through the heart to the point of bifurcation, from which the fluid passes through the channels in the edges of the plates, and over the exposed surface of the yolk between them. Each pulsation occupies 1½ seconds in traveling from the tip of the body to the umbilicus of the yolk-sac. The pulsations occur in series with intervals of repose between them, which sometimes last for three or four minutes. The pulsations of each series follow each other regularly at the rate of one per second, so that while one wave of pulsation is progressing through the free edges of the mesodermic plates another one has originated in the posterior end of the dorsal vessel.

The secretion of a cuticular covering by the ectodermic layer begins first on the ventral surface of the body. The appendages appear to be simultaneously enveloped by the secretion, which closely encases them; however, soon after the closure of the dorsal wall and the secretion of the cuticula in this region, the whole layer becomes distended with a fluid and is thereby removed from the body. At the ends of the appendages the cuticula is swollen into a bulb-like enlargement which allows a free movement of the tip of the growing limb; this is especially noticeable in the antennae, which at this time are rapidly increasing in length. The embryo soon comes to fill completely the cavity of the egg; the legs are now folded upon themselves, pl. 19 figs. 4 and 5; the antennae curve around the end of the abdomen and reach nearly to the head on the dorsal side. The embryo has attained its full size and is enveloped by two cuticular layers,—the primitive layer surrounding the body like a loose sac, and the secondary cuticula closely investing the hypodermis. The outer layer shows only a few irregularities of surface, while the inner layer is produced into innumerable spines, bristles, and hair-like processes. (Pl. 19, figs. 14 and 15.) The mouth parts have grown shorter and stouter, while the cuticula of the mandibles and the inner lobes of the maxillae has become much thickened to form the biting mouth parts. The yolk has been consumed during this interval of growth and the digestive tract is completed in all its essential parts. The body walls have become thinner as the internal organs acquired their relative proportions, so that they now consist of a thin hypodermal layer surrounded by its tough cuticula. The food supply being exhausted, the embryo bursts its membranous coverings and becomes free.

The foregoing summary of the changes through which the embryo passes from the time of revolution until it leaves the egg will be of service in properly connecting the following detailed account of the development of the separate structures of the now complicated animal. In order to simplify the matter, I will treat each of the following subjects in a separate paragraph.

1. Alimentary System.
   a. Proctodaeum and Malpighian tubes. b. Mesenteron, pyloric caeca and yolk. c. Stomodaeum and salivary glands. d. Corpus adiposum and pigment bodies.
2. Circulatory System.
   a. Heart and blood corpuscles. b. Lateral and ventral blood sinuses.
3. Respiratory System.
   a. Embryonic gills. b. Tracheae.
4. Nervous System.
   a. Ventral cord. b. Brain. c. Suboesophageal ganglion and commissural cords. d. Dorsal cord.
5. Sexual Organs.
   a. Germinal cells. b. Ovaries and Testes.
6. Germinal Layers.
   a. Ectoderm, its origin and derivatives. b. Mesoderm, its origin and derivatives (splanchnic and somatic layers), and body cavity. c. Endoderm, its origin and derivatives.

The PROCTODAEUM has the shape of a pocket at the time of revolution but it soon elongates into a tube ending in an enlargement resembling the cap of a mushroom (pl. 18, fig. 26; pl. 19, fig. 1; pl. 22, fig. 1; Fig. 26). It is composed of two separate layers, an inner epithelial, derived from the ectoderm, and surrounding this a muscular layer derived from the splanchnic layer of the mesoblast. The latter is continuous with the muscular coat of the mesenteron and stomodaeum. When the tube has elongated so that its enlarged end lies within the fourth or fifth segment of the abdomen (counting from behind forwards), there arises near the free end in the median dorsal line a small, trilobed, hollow bud of the ectodermic layer, opening into the lumen of the tube. Each lobe grows rapidly into a small tubular organ, the primitive Malpighian vessel. Each of these bifurcates at some distance from the proctodaeum, so that there are ultimately six of the tubes. The one lying in the median dorsal line grows backward for some distance along the proctodaeum; the two lateral tubes curve in various directions through the body cavity. At the time these vessels appear the proctodaeum is connected by a dorsal mesentery with the heart. (Pl. 23, fig. 5.) The lumen of the proctodaeum is at first circular in cross section, but as the layers thicken the epithelial lining is thrown into six equal longitudinal folds, which in the anterior part of the tube at this stage almost obliterate the lumen. These folds are parallel and extend the greater part of the length of the tube. The lumen of the proctodaeum becomes continuous with that of the mesenteron only some time after the muscular layer of these two parts have united. At the time of hatching all traces of the union of the parts have disappeared, but in cross section the mesenteron is still much larger than the proctodaeum.

Fig. 25. Optical sagittal section of stomodaeum before its union with the mesenteron. × 125.

The STOMODAEUM (pl. 19, figs. 2, 4 and 13; pl. 22, fig. 1; Fig 25) early assumes a tubular condition, but it does not unite with the mesenteron until after the closure of the body walls. It extends from the mouth opening back into the region of the second thoracic segment, and in its growth pushes itself into the mesenteron, carrying before it the wall of the mid gut. The portion of the mesenteron which projects in front of the posterior end of the stomodaeum is subsequently converted into the pyloric caeca of the adult animal. Like the proctodaeum, the stomodaeum ends blindly at first, but its cap is not so marked as that of the former. At the time of revolution there appears a pocket in the median dorsal line similar to that formed in the proctodaeum for the Malpighian tubes. The fate of this pocket is unknown. Upon the union of the stomodaeum with the mesenteron, the alimentary tract is converted into a continuous tube. In cross sections of the embryo one finds the epithelial layer of the stomodaeum thrown into six longitudinal folds, which at first nearly fill its lumen; but by its subsequent increase in circumference they are reduced to ridges along the inner surface of the canal. In the anterior portion of the stomodaeum the dorsal fold is larger than the others and is frequently bilobed. (Compare the sections shown in pl. 21, fig. 37; pl. 22, figs. 11, 15; pl. 23, figs. 1, 2, 4.) The stomodaeum passes through the nervous cord between the brain and first ventral ganglion. The invagination for the alimentary tract having taken place before the formation of the nervous cord, the latter is in consequence compelled to grow around the stomodaeum in order to unite with the brain. The stomodaeum forms, by an enlargement near its posterior termination, the proventriculus.

Fig. 26.

Optical sagittal section of proctodaeum before the Malpighian vessels arise. ×250.

Although the SALIVARY GLANDS arise as invaginations of the ectoderm (pl. 23, fig. 1) of the ventral surface of the mandibles, yet they soon come to unite with the oesophagus by a common duct (pl. 18, fig. 16) and, from the subsequent shortening of the oesophagus, to empty into the floor of the mouth. The invaginated portions extend upward toward the dorsal line of the body in the form of a solid, curved rod of thin-walled spindle-shaped cells. The nuclei of these cells are equal in size to those of the ganglionic cells and besides exhibiting a distinct nucleus, they are connected with the central fibre of the rod by what is apparently a portion of the nuclear membrane. The rods are ultimately directed backwards and reach into the abdominal cavity. A short distance back of their union into a common duct, each gland bifurcates. They never become convoluted as do the Malpighian vessels. Before hatching, all trace of their origin has disappeared. No evidence of the existence of the *spinning glands* of other groups was found at any time, although I have carefully studied my preparations of the early stages for the invagination in the upper lip from which they arise, and those of later stages for the glands themselves. The uniform result has been the failure to detect any structure that could be interpreted as belonging to these organs.

The part of the MESENTERON (pl. 19, figs. 4 and 5; pl. 22, fig. 1) which is first formed within the body of the embryo is a sheet-like extension of endodermic cells along the germinal band in contact with the yolk. It is pushed away from the head region by the growing stomodaeum and from the posterior abdominal region by the proctodaeum, so that it is confined to the thoracic and anterior abdominal segments. In the region of its contact with the proctodaeum the walls of the mesenteron are thrown into folds. At present I am unable to say whether these folds go to form diverticula of the mid gut or disappear altogether. The large yolk cells which, as has been stated, appose themselves to the germinal band to form the mesodermic elements are not all employed to form the middle germinal layer, but some of them become arranged as a superposed layer, — the endoderm. At an early stage one cannot distinguish between these cells, whether they are to form mesodermic or endodermic elements. Previous to the time of revolution the mesenteron is formed slowly, but after this act it rapidly becomes a definite sac enclosing the yolk mass. The anterior end of the mesenteron is in connection with the serosa sac, and since the latter passes bodily into the embryo, its cells grade so insensibly into those of the walls of the mesenteron that it becomes difficult to distinguish the place where one begins and the other ends. After revolution the yolk passes from the yolk sac into the mesenteric cavity through a circular opening in the body wall (i. e. amnion) back of the head. (Pl. 19, figs. 1, 2; pl. 22, fig. 1.) It is forced into the body of the embryo by the contraction of the walls of the yolk sac. As a consequence of this continued thickening and contraction, many of the nuclei of the serosa cells are set free from their cells and pass with the yolk into the body through the circular pore back of the head. After passing this point some of them find their way at either side of the oesophagus into the body cavity, while others go directly into the open end of the heart; the majority of them, however, pass with the yolk into the enteric cavity and aid in the assimilation of this mass. The remnant of the yolk sac is seen for a time as a plug-like projection from the median dorsal wall behind the head. It ultimately passes into the body cavity and is absorbed. When within the embryo there is a faint lumen between the apposed walls of the yolk-sac, which is continuous with the cavity of the mesenteron. (Pl. 19, figs. 4, 5; pl. 22, fig. 1; pl. 23, fig. 2.) Up to the time of hatching the mesenteron is more or less distended with yolk matter and its walls are in consequence very thin, but as the yolk is assimilated the walls become thicker and the diameter of the tube is much diminished.

Owing to the rapid growth of the embryo after revolution, the yolk mass is quickly taken within the body walls. The greater part of it is consumed before the walls are closed. The assimilative function is so active that the amount of food prepared exceeds the amount that can be made use of by the growing tissues, and in consequence this surplus is stored up in two dorso-lateral FAT BODIES (pl. 19, fig. 1), which lie on either side of the heart and extend from just back of the head to the tip of the abdomen. These bodies are yellow, reach their greatest development soon after the closure of the dorsal wall and have entirely disappeared at the time of hatching. In pl. 19, fig. 12, is shown one lobe of the corpus adiposum of the left side. It is an irregularly shaped lobe composed of loosely connected grayish corpuscules. The lobes, one to each segment, project outward from the longitudinal connecting body. Within the grayish mass are numerous yellow fat-drops and an irregular network of black pigment. The muscular wall of the mid gut is formed by the splanchnic mesoblast before revolution. About the time of revolution, however, there is deposited upon this layer another, which at first is very thin and irregular. After the dorsal wall of the abdomen is closed over, the mesoderm is quite well formed in the region of the proctodaeum. (Pl. 22, figs. 1, 9.) The cell walls are very indistinct (if present at all) and cannot be made out on specimens treated with osmic-acetic acid solution. The nuclei vary in size but are usually somewhat larger than the nuclei of the surrounding splanchnic mesoblast. The protoplasm of the endodermic cells forms an irregular outline on the inner surface of the layer. Here and there may be seen the large endodermic nuclei which have come to the surface of the yolk mass to fuse with the inner wall of the mesenteron and to furnish by subsequent division the nuclei of other cells. The splanchnic mesoblast has been separated into two parts, a muscular layer in contact with the endoderm, and an epithelial layer of exceedingly thin flattened cells continuous with the lining of the body cavity. The cells of the epithelial layer are spindle-shaped in cross section and occur at irregular intervals. (Pl. 22, fig. 9.)

The formation of the HEART does not begin until after the revolution of the embryo. It is first to be distinguished in the abdominal region about the time of the closure of the dorsal ectoderm. With a magnifying power of 125 diameters it appears (pl. 19, figs. 1, 5; pl. 22, fig. 1; pl. 23, fig. 5) as a delicate tube with here and there nuclei lying in contact with its wall, but when more highly magnified the wall is seen to be double. In the formation of the heart, the lateral plates of mesoderm grow upward around the mesenteron, and as their edges approach the median dorsal line there is seen to be in each a tube. These two plates coalesce in the median line and their tubes unite into one — the heart, or dorsal vessel.

The mesoblastic plates are not divided in this region into splanchnic and somatic layers until after the formation of the heart.[1] (Pl. 22, figs. 10, 11, 12, and 14; pl. 21, figs. 32, 33, 34, 35, 36, and 41.) In cross sections of the embryo in the stage represented in pl. 22, fig. 1, the origin and formation of the heart may be traced satisfactorily, and, as has been shown above, it does not differ from the formation of the heart in Lumbricus as described and figured by Kowalevski (loc. cit. p. 25, pl. 7, fig. 23). In this stage the heart is a V-shaped organ, with the stem of the V directed backwards, but as the limbs of the V approach each other they fuse and in this manner form the single tube of the dorsal vessel. The formation of the permanent vessel keeps pace with the growth of the dorsal ectoderm from behind forwards.[2] The histological elements composing the heart in Oecanthus deserve especial mention. The primitive tube of each mesodermic plate is formed by a row of cells, each one of which becomes ((shaped, and then by the fusion of the lips of the ((it acquires a (( )) shape. (Pl. 21, figs. 33 and 36.) These are the muscle cells of the wall of the heart. The nucleus lies in the outer part of each cell. In some sections the mesodermic plates appear to be composed at their upper edges of amoeboid cells, so that in some parts the heart does not have any structural connection with other portions of the body at this stage. In such a section the wall may be destitute of nuclei, and the heart then appears as a single-walled, round, oval or D-shaped vessel. Its cavity, before and after the fusion of the two parts, is filled with the same coagulable fluid that fills the body cavity. Mesodermic cells, such as compose the wall of the heart, are found free both within and without the vascular cavity at this stage. It is probable, however, that all these

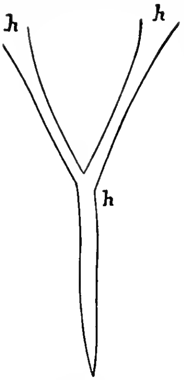


Fig. 27.
Diagram of the half-formed heart. *an.* its posterior end.

[1] Compare Bütschli (11).

[2] Compare the account by Claus (13) of Branchipus where the heart is formed first in the head region and extends into the abdomen at a later period.

cells assist in forming the walls of the blood canal and do not become blood corpuscles. There are given off from either side of the heart two thin sheets of mesoderm (pl. 23, fig. 2), one above and one below the middle line. These unite at a short distance from the vessel on either side, but immediately diverge again into what appear, upon cross section, to be a pair of more or less circular vessels extending in a plane parallel to, but below, the heart. In the membrane thus stretched between these vessels and the heart there are usually a number of nuclei having the same size and appearance as those in the wall of the heart. From the outer sides of these lateral tubes, mesodermic elements diverge in the form of a varying number of sheets (in some instances there are as many as four, but more commonly only two), which join the somatic layer of the mesoderm. After the formation of the heart there appears in the thoracic and maxillary regions below the nervous cord a tube of about the size and shape of the dorsal vessel. (Pl. 21, fig. 41.) It is a ventral blood sinus similar to the two latero-dorsal tubes just described. In the posterior abdominal region, about the time of the appearance of the Malpighian vessels, the heart is connected with the proctodaeum by a dorsal mesentery similar in structure to the sheets just described. In embryos treated with osmic-acetic acid the heart, like the body cavity, is at this time found to be filled with a finely granular substance, probably coagulated plasma, which appears grayish in reflected light and is faintly stainable. (Pl. 22, fig. 10.) During the contraction of the yolk sac most of the nuclei of the serosa cells which are then set free pass into the mesenteron, but, as has been stated in a previous paragraph, some of them pass into the body cavity and after further transformation find their way into the heart. These serosa nuclei become large and vesicular during the decline of the yolk sac, and their nuclear substance breaks up into several irregular masses connected together by a few coarse filaments and numerous granules. In this stage they are freed from the surrounding cell, the protoplasm of which during this time has become thin and watery. The nuclear membrane is seen to be a delicate, structureless, scarcely stainable vesicle surrounding the nuclear substance. If the nucleus passes into the mesenteron with the yolk, it does not undergo any marked transformation and may either disintegrate or proliferate and form, by collecting protoplasm about itself, from one to several amoeboid endodermic cells. If, on the other hand, the nucleus passes into the body cavity (pl. 22, fig. 1) it becomes more vesicular, its membrane much thinner, while nearly all of the stainable substance is promptly concentrated into the nucleolar masses, and ultimately all of the nuclear substance goes to form from one to three spherical bodies which are surrounded by the common membrane. These bodies are blood corpuscles and are free nucleoli immediately on the rupturing of the vesicle which surrounds them. (Pl. 22, figs. 1 and 3.)

The invaginations of the ectoderm which form the TRACHEAE do not occur so early in Oecanthus as they do, according to Kowalevski (26), in Hydrophilus, neither do they occur on the ventral surface of the segments, as Kowalevski has represented in his pl. 8, fig. 10. On the contrary, one does not find the tracheal pockets until after the embryo has revolved in the egg and the dorsal wall is partly closed. They then appear as invaginations of the pleural region.

There are to be seen in sections of the head segment, at the time when the invaginations to form the salivary glands are well advanced, small infoldings of the ectoderm similar in position to the invaginations of the thoracic and abdominal segments which form the tracheae; but at present I am unable to say whether these ingrowths form any portion of the tracheal trunks, as they do in Lepidoptera according to Hatschek, or become transformed into chitinous rods forming part of the internal skeleton of the head, as Tichomiroff has describedfor Bombyx mori. They probably disappear altogether, as no trace of them was to be found in sections of an embryo about the time of hatching. A final decision on this point is reserved until further study can be made. In the embryo at the time of hatching there are two main tracheal tubes which extend along the sides of the body from the end of the abdomen where they are smallest, into the thoracic segments. The stigmatic openings, as well as the tracheae which supply the organs of the body, are all connected with these trunks.

The respiratory function of the embryo is first indicated at the time of revolution by the appearance of paired lateral outgrowths of the ectoderm from the pleural region of the first abdominal segment. These GILLS or respiratory organs come to lie just behind, but dorsad of the base of the third thoracic appendage. (Pl. 19, figs. 1, 17; pl. 22, figs. 13 and 14; pl. 25, fig. 29.) In outline they are broadly oval or kidney-shaped and are united to the body by a short peduncle springing from the centre of that face of the disc which is in contact with the body of the embryo. These folds are cellular structures and at different periods are solid or hollow. The cells of the folds early lose their ectodermic characters and become somewhat larger than those of the adjacent body wall. In the fresh condition they appear enucleate and coarsely granular, but upon treatment with osmic ora cetic cid a nucleus is distinctly visible. In surface view there is to be seen a clear central area which indicates the position of the internal cavities of the gill. These cavities are continuous with the body cavity and probably serve as channels through which the vascular fluid circulates. They vary in shape and relative proportions. The relations of these appendages to the body is best seen in sections. (Pl. 22, figs. 13, 14.) The out-growing flap is here seen to project over an invagination immediately below it and in some instances to become apposed so closely to the body wall as to convert the open pocket into a closed canal. In its middle part, where the fold fuses with the body, its cells are separable into two irregular layers which correspond to the two primitive plates of the fold, but they fuse completely, or become widely separated, in the free portion of the pad. These appendages reach their greatest degree of development soon after the revolution of the embryo, and then gradually atrophy, entirely disappearing before the complete closure of the body walls. In sections of the gill organ before its atrophy (or absorption) one finds both distinct canals and lacunar spaces (pl. 22, figs. 13, 14), which radiate from the point of connection of the pad with the body, and these together with the arrangement of the cells give the radiate stucture characteristic of the fresh gill. The canals are generally circular in section and pursue irregular courses throughout the cell substance, while the spaces are developed by the separation of adjacent cell walls and are irregular in outline and occur at varying distances from each other. The gill pad is essentially a single-layered sac, with a much constricted neck, evaginated from the pleural region of the abdomen. The protruding organ is flattened against the body of the embryo and by this means the cells are rendered spindle-shaped. The nucleus of each cell lies in that part of its cell which is farthest from the constriction of the organ. The cell wall gradually tapers to a point and ends near the neck. The cells are bent in various ways depending upon the relations of their nuclei to the wall of the pad. The only larval organs which in any way resemble these are, so far as I am at present informed, the peculiar mushroom-shaped bodies described by Rathke (38, pp. 27–32, Taf. 2, figs. 1–5) for Gryllotalpa. The author considered them to be respiratory in function but he was not able to establish his interpretation.

The central NERVOUS SYSTEM, which made its appearance early in the development of the embryo, is still united with the ectoderm at the time of revolution, but with the completion of this act, which seems to add a new impulse to the development of the entire organism, the ganglionated cords that form the nervous system of the thoracic and abdominal regions become cut off from the superficial ectoderm and lie free within the body cavity. The median cord, which was formed by a modified invagination of the superficial layer of the ectoderm, immediately fuses with the lateral cords along its dorsal and lateral surfaces, but its ventral surface still forms a portion of the ventral surface of the body of the embryo. By the overgrowth of the superficial cells on either side of this cord it becomes inclosed within the body. These three parts of the nervous system now form a single nodulated rod which has no structural connections with the rest of the body, nor with the brain. Since the enlargements of the two lateral cords occur at regular intervals and opposite each other, each segment of the young embryo is furnished with two ganglia, but when the median ingrowth passes between and fuses with them, they become structurally connected by two bundles of fine transverse filaments which arise out of the substance of this invaginated part. These bundles of fibres do not remain distinct but soon fuse, after which they are seen to connect the central portions of the ganglia. Between the successive pairs of ganglia the median ingrowth atrophies, and at the time of the closure of the dorsal wall of the body there is seen between the connecting cords of two adjacent pairs of ganglia, a small triangular or cylindrical mass of cells, concerning the fate of which I am not absolutely certain. I believe, however, that they go to form a part of the internal skeleton. The chitinous rods in the thoracic region to which the muscles of the legs and wings are attached probably arise from the remnants of this median invagination, but in the abdominal region they may disappear entirely without giving rise to such structures.

The two lateral ganglia of each segment ultimately become fused into one, so that on dissecting out the nervous system of the embryo represented in pl. 19, fig. 4, all the ganglia presented the appearance represented in pl. 19, fig. 9. They are ovoid bodies connected by two longitudinal commissures which at this stage are so short as to leave the ganglia in contact with one another; later these long commissures increase much in length and the ganglia thus become widely separated. Before hatching the three ganglia of the maxillary region (i. e. the primitive pairs of ganglia supplying the mandibles, the first and the second maxillae) fuse into one mass[1] — the *suboesophageal ganglion*. This nervous centre is the largest in the body with the exception of the brain, which it nearly equals in size. In pl. 21, fig. 39, is figured a section through this ganglion before the fusion of its fibrous portions. The fibres of the longitudinal commissure are similar to

[1] Graber (21, page 428), says that in insects the ganglia of the mandibular segment become the commissural cords, and that the suboesophageal ganglion is composed of the primitive ganglia of the first and second maxillary segments. He does not affirm, however, that he has himself observed this to be the case. It is improbable that there exists in different insects such a difference in the manner of the formation of the commissural cords and the suboesophageal ganglion.

those of the cross commissures and arise from the ganglionic cells of the lateral cords. In longitudinal sections of the cord (pl. 22, fig. 1) one finds the longitudinal commissures extending as unbroken bundles of fibres from the brain to the last abdominal segment. The portion in the brain is of two or three times the size of that in the hind abdominal region. In transverse sections (pl. 23, figs. 1 and 2) it forms a varying proportion of the cord, dependent upon the part of the ganglion through which the section passes as well as upon the region of the body from which it is taken. During its passage through each ganglion it suffers a slight enlargement, which is augmented by the decussation of fibres from the adjacent surfaces of the two long commissures through the cross commissures. The fibres of the longitudinal and cross commissures remain distinct from one another until quite late in embryonic life, when the peripheral fibres of the long commissures become woven among some of the fibres of the cross commissures. (Pl. 22, fig. 6.)

The BRAIN (pl. 19, figs. 6, 10; pl. 20, figs. 22 and 23) is developed as two separate kidney-shaped lobes from the internal cell mass of the ectoderm of the head folds, and hence corresponds in its origin to the lateral cords of the thoracic and abdominal regions, but the invaginated median element is lacking here, and the union of the two lobes is on this account accomplished only at a very late date. The union of the brain with the ventral nerve cord is accomplished shortly before revolution. The posterior portion of each lobe is prolonged backward for a short distance and unites with the anterior ends of the lateral cords which are prolonged as far as the upper border of the oesophageal opening. The union of the two lobes of the brain is accomplished by the coalescence of outgrowths from their median surfaces near the posterior end of either lobe. In cross sections of the brain (pl. 22, fig. 1; pl. 23, figs. 1, 3, 6, 15) the fibres are shown to be limited to the central portion of the mass of ganglionic cells, while in the ventral cord they lie dorsad to the centre. The most of the fibres in the brain appear to form concentric layers, the remainder curving about in all directions, giving the fibrous mass the appearance of a felt work in which a few of the fibres are larger and more sharply defined than the others. In the ventral ganglia the fibres are arranged principally in the direction of either the long or the cross commissures. The fibres of each cross commissure are collected into two[1] bundles more or less closely united, depending upon the development of the embryo, while those of the long commissures remain permanently distinct from one another. The nerves of the adult insect are, in their basal portions at least, simple outgrowths of the fibres of the cross commissures, each with a sheath of ganglionic cells. At the time of the closure of the body wall, they are finger-like processes and they, like the outgrowing ocellar and antennal nerves, project in pairs from either side of the ganglia. (Pl. 20, figs. 22 and 23.) The ganglionic cells give rise to the fibrous portion of the nervous system, probably by the prolongation of their cell walls into filaments. Pl. 22, fig. 2, shows the nucleus of a single ganglionic cell, from the periphery of which fine filaments radiate and pass into the

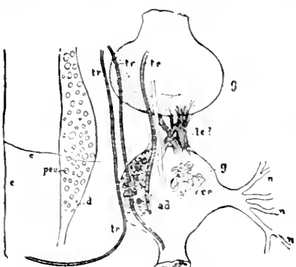


Fig. 28.

Ventral nerve cord and other structures as seen from above. The ganglia are connected by a mass of cells below the fibres, *l. c.* of the figure. The l. com. probably contains most of the commissural fibres. The ganglia are entirely covered by a reticulum within the meshes of which are seen fat bodies. Along the median dorsal line there is seen a delicate tube containing a non-corpuscular fluid. Six tracheal branches extend over the surface of the ganglion. On either side of which are seen the lateral blood sinuses. From a living embryo. × 400.

[1] Compare Bobretzky (6).

fibrous portion of the brain, leaving a cavity about the nucleus and its radial fibres. The nervous cord in the hatched embryo embraces 17 pairs of ganglia. Numbering from before backwards, 1, forms the brain ; 2, 3, 4, the suboesophageal ; 5, 6, 7, the thoracic ; 8–17, the abdominal ganglia. During embryonic life the brain shows no traces of the specialized parts (e. g. calices, trabeculae, central body, etc.) found in the adult. In pl. 22, fig. 1, are figured three pairs of large nuclei which occur in the adjacent walls of the successive thoracic ganglia. Pl. 22, fig. 7, represents these nuclei more highly magnified. No nuclear membrane is distinguishable. The nuclear substance appears finely granular in the sections, and near the centre of each of the nuclei occupying the anterior edge of a ganglion is a bar-shaped nucleolus, while the nuclei lying in the posterior edge of a ganglion possess several small round nucleoli. The significance of these nuclei is unknown. The optic lobes (pl. 20, figs. 22 and 23) are first seen as rounded projections on the outer surface of the hind part of each half of the brain. By a gradual growth they appose themselves to, and finally fuse with, the much thickened ectoderm near the base of the antennae.

Before the differentiation of the optic lobes of the brain, the ectoderm just posterior to the base of the antennae is raised into a pair of lenticular elevations which ultimately form the ectodermic parts of the eye — i. e. the cornea, lenses, rods, and retina. (Pl. 23, fig. 16.) The cells in this elevation are at first colored with a brown pigment, but the color disappears about the time of the closure of the dorsum. The surface of the elevation becomes papillate by the projecti n of the cells which form the simple lenses. This condition persists (pl. 20, fig. 47 ; pl. 25, fig. 31) until after the first ecdysis of the hatched insect, when the cornea becomes smooth and glassy.

The following table is self explaining : —

	Origin.	Fate.
A. **Ectoderm.** —	From the superficial cells on the dorsal side of the egg in the future cephalic region.	It becomes the "hypoderm" of the body and its appendages,—the gills, wings, and ventral appendages,—also the nervous system, the tracheae, the epithelial lining of stomodaeum and proctodaeum, the salivary glands and the Malpighian vessels ; and forms by secretion the cuticula of the first three structures.
B. **Mesoderm.** —	From indifferent yolk cells ; from the inner ends of the cells of the germinal band (?).	It becomes, muscular layers of the enteric tract, sexual organs, heart, segmental muscles, peritoneum, and segmental organs (?).
C. **Endoderm.** —	From indifferent yolk cells ; from the superficial cell layer—the blastoderm or yolk sac.	It forms the epithelial lining of the mesenteron and furnishes the corpuscles of the vascular fluid.

The germs of the sexual organs do not appear until after revolution and the beginning of the formation of the dorsum. (Pl. 22, figs. 1, 4, 5). They are first seen as two irregular groups of amoeboid cells, belonging to the splanchnic layer of the mesoderm on either side of the dorsal vessel. Later they assume the form of spherical masses, which soon elongate, becoming first oval, then cylindrical and finally pear-shaped. The ovaries at their anterior ends become small and rod-like, and the anterior end of each rod is connected with the mesodermic elements lying along the wall of the heart. In the enlarged portion of the mass there appears a space comparatively free from germinal cells but filled with a finely granular protoplasm; in this area are to be seen a few nuclei — with peculiar bar-shaped nucleoli — which are much larger, and also more sharply defined, than the nuclei of the remaining germinal cells. These are the nuclei of the primitive ova and probably give rise to all of the ovarian germs. At a later date each ovarian body is differentiated into fifteen or twenty ovarioles — which include the greater part of the cell mass — and an oviduct which is formed as an out-growth from the hind end of the mass. The details of the tubulation of the ovarian masses and the distribution of the germinal cells require further study.

At the time of revolution the appendages exhibit traces of their future subdivisions. The antennae are about one half as long as the embryo and are comparatively thick. The mandibles are much broadened and slightly trilobed. Both pairs of maxillae are distinctly trilobed and are much longer than the mandibles. The three pairs of thoracic appendages are of nearly equal length, but the third pair exceeds the other two in bulk. The basal joints of all three pairs are considerably enlarged, but their tips are as yet rounded. Soon after revolution they increase rapidly in length and become sharply bidentate. The first pair of abdominal appendages have nearly disappeared, while the anal stylets, or last pair of abdominal appendages, has grown to the length of the mandibles, and at the close of embryonic life have acquired considerable size and are covered with hairs.

After the yolk sac is formed a cuticula is secreted about the embryo, but it does not quite reach to the edges of the yolk sac and is much thinner on the sides than on the ventral surface of the embryo. This layer is soon cast off and a second one secreted. From the latter are derived the thick chitinous parts of the mandible and maxillae, the onychia and tibial spines of the legs, and the balloon shaped processes of the anal stylets. With the growth of the embryo, the maxillary and mandibular regions of the body are greatly shortened, their dorsal portions disappearing altogether and their ventral portions fusing with the oral region. Both pairs of maxillae become somewhat reduced in size and with the mandibles completely cover the mouth opening. They are in turn covered by the broad labrum, which has now been reduced to a thin chitinous flap. (Pl. 19, figs. 7, 8; pl. 20, figs. 45, 46.)

After the secretion of the second layer of cuticula the surface of the body is thickly beset with bristly hairs. They are especially developed upon the antennae and anal stylets. On the inner surfaces of the basal portions of the latter are seen two vesicular bodies (pl. 19, figs. 14, 15, 16) which from their structure and position can be only modified hairs. They appear after the first ecdysis and then only one upon each stylet. Subsequently they increase in number, probably with each ecdysis, until in the adult insect one finds on each from ten to fifteen such bodies. The cuticula at the base of the organ is raised up in the form of a vase, from the depth of which the stem of the balloon takes its origin. The latter is filled with clear vesicular bodies during the period of embryonic life, but appears to be entirely empty in the adult.[1] At the time of hatching there are no traces of wings, but later these appear as flat outgrowths of the dorsal ectoderm and in the man-

[1] These organs may possibly be homologous to the sense organs found on the anal stylets of other Orthoptera. Compare Packard's description of those met with in Blatta. Amer. Nat. vol. IV., p. 620.

ner of their formation closely resemble the ventral appendages, except that they are retsricted in their growth by the cuticula and only increase in size at each ecdysis. The ectoderm of the insect has now lost its cellular character and constitutes a syncytial layer in close contact with the inner surface of the cuticula.

The serosal membrane of Oecanthus affords exceellent material for studying the structure of the cell and the changes which its different parts undergo during the process of division. In Fig. 17 is represented a portion of the fresh serosa, treated with dilute acetic acid. The reagent is just beginning to affect the cells. Adjacent cells are joined together by intra-cellular matter which is to be considered as belonging to the cell substance. Near the centre of each cell is seen the usually spherical nucleus. Before the reagent had affected them, these nuclear bodies appeared to be filled with a finely granular protoplasm, — often showing a bipolar arrangement, — which contained from one to three highly refractive nucleoli. Sometimes a small area was to be distinguished about one, or each, of the nucleoli. The boundary of the nucleus, although sharply defined against the cell protoplasm, seemed to fade insensibly into the nuclear substance. After the action of weak acid the membrane showed a sharp double contour and the nuclear substance became more coarsely granular. Some of the nucleolar bodies are seen to be centres from which the nuclear substance radiates either in the form of distinct fibres or as rows of granules. Many of these rays are finally deflected toward, and centre in, the opposite pole. In nuclei in which two or three of these bodies are present, there are frequently seen two centres of radiation between which lies the third nucleolar mass. This third body corresponds, in its relative position to the centres of attraction, with the so-called Zellplatte in the process of cell division. (Fig. 17; pl. 21, figs. 15, 16, 17, 20, 22.) In other nuclei there is seen a distinct spindle structure, at either end of which are placed the nucleoli which thus form the centres of radiation. (Pl. 20, figs. 32, 33.) The stages in this process of nuclear division are evidently very similar to those which have recently been described for *cell*-division by numerous writers.[1] One sometimes finds within a single cell wall two nuclei lying in contact (pl. 20, fig. 31), — each of which contains a nucleolus with radiating filaments similar to those of the single nucleus, — and in such mutual relationship as to indicate that they had arisen by a process entirely analogous to that of cell division.

The nucleolar bodies lie at opposite poles of the nucleus but are always surrounded by the nuclear substance and hence do not come in contact with the nuclear membrane. The granules of the substance lying between them are disposed in straight lines which are separated by tracts of clear protoplasmic substance, while from numerous points on the periphery of the polar corpuscle the nuclear substance radiates either in the form of distinct fibres or rows of granules. (Pl. 20, fig. 33.) Pl. 21, fig. 47 is a section through the nucleus of a blastodermic cell, exhibiting two nucleolar bodies, which lie within a space free from nuclear granules or filaments. The bodies are separated by a thin layer of nuclear substance, which is probably an optical section of the nucleolar plate. The body of the nucleus is filled with fine tortuous filaments of nuclear substance.

[1] I cannot assert positively that the spindle figures which I have seen in the *nuclei* of serosa cells of Oecanthus arise in the same manner as in cells or produce the same effect upon the nucleus as they do upon the cells in other instances, since I have not observed the sequence of phases in any one nucleus. It is more than probable that such is the case, since in a single preparation of serosa are to be found nuclei exhibiting all stages in the phenomena of spindle-formation and division. Compare Flemming (17, 18), Priestly (37), Strasburger (39) and the synopses of these papers by Mark (30).

In the nuclei of the epithelial cells from the follicles of the ovariole of Oecanthus (pl. 21, figs. 43–50; pl. 23, figs. 17, 18, 20) the nucleoli vary greatly in shape and number. There may be a single spherical or dumb-bell shaped nucleolus, or the latter may assume the condition of a thick rod. It may be lacking entirely or may consist of a central body with few or many, small or large, radiating threads. Whenever more than one nucleolar body is present the nucleus is more or less elongated and usually shows some indications of approaching division. The occurence of anything like a symmetrical nuclear spindle is rare in such cells. The arrangement of the nuclear substance in the form of filaments is exceedingly various, but out of all the material studied, I have not been able to trace any definite cycle of conditions through which the nuclear filaments pass during the division of the nucleus, such as has been described by Flemming, Strasburger and others for both animal and vegetable cells. However, many of the stages which I have observed correspond to those given in their schemes of cell division. The most common form of filament as a short, tortuous, refractive thread, which is woven into a filamentous mass so as to be traceable for only short distances in any direction. This thread may appear moniliform or continuous.

The filamentous structures of the germinative vesicle at various stages in the growth of the ovum, although characteristic, do not differ in essential particulars from similar structures in tissue cells. In the follicular epithelium the threads are frequently arranged in loops at the periphery of the nucleus while at their central ends they are connected with the larger masses of nuclear substance, — nucleoli.— from which they may be said to spring.

The physical and chemical conditions of the yolk nuclei differ considerably from those of the nuclei of tissue cells, as is at once apparent upon treatment with reagents. The yolk nuclei are larger than any others in the embryo and are less numerous. They multiply much faster, but their descendants usually differ greatly from them, as for example when a single yolk nucleus by rapid proliferation gives rise to many mesodermic nuclei. When treated with osmic acid and Beale's carmine the nuclear matter separates into two distinct parts, the nuclear fluid and the nuclear substance. The latter is usually contracted into an irregular mass near the centre of the nucleus, but the compactness of this central mass depends entirely upon the kind and strength of the reagent used. If the reagent is too strong, the nuclear substance will be entirely torn away from the membrane and be contracted into an apparently homogeneous mass, but if a weak solution is used many of the filaments will still retain their connection with the nuclear membrane, whereas the central mass will appear finely granular with here and there filaments stretching out toward the periphery of the nucleus. The spaces between these radiating filaments are filled by a feebly stainable substance, the nuclear fluid. The nucleoli do not stain so deeply as the filaments, and the membrane stains scarcely at all. The size and condition of the nuclear filaments vary greatly in different nuclei and, consequently, one infers in different stages of the growth of the same nucleus. The nucleolus is not always present, but when it is, the nuclear filaments are usually seen to be more closely intertwined in its vicinity than in other parts of the nucleus. The nucleolus may appear filamentous or homogeneous in its structure; in the latter case the nuclear filaments have no connection with it. Sometimes the nucleolus may be enveloped in a clear mass of protoplasm in which no filaments are to be detected. Such nucleoli are probably the homologues of the polar corpuscles which appear in the process of segmentation. There exists this striking difference between the two cases, that whereas in most cases the nucleoli (polar corpuscles) are placed in the cell protoplasm, in the case of the serosa nuclei the corpuscle lies within the membrane of the nucleus, and the division of the latter does not at first seem to affect the condition of the cell.[1] (Pl. 20 figs. 30, 31.) Such a cell immediately after the division of the nucleus is practically in the condition of a syncytium. The relations of the nucleolus to its fibres and to the nuclear fluid are distinctly shown in sections of endodermic nuclei. (Pl. 21, figs. 5, 11, 12.)

As regards the origin and significance of the primitive germinal layers among the Insecta, I am still in doubt. Balfour's interpretations and general conclusions (loc. cit., Vol. I, p. 378 ; Vol. II, p. 278) I cannot accept since they seem at variance with the facts. The author considers the superficial cell layer existing at the close of the formation of the blastoderm equivalent to ectoderm (epiblast) and the inclosed yolk mass as essentially endoderm. But when we consider the rôle and subsequent fate of these two layers it at once becomes apparent that such a view does not accord with the facts, for the blastoderm ultimately forms the entoderm (mesenteron), and the ectoderm, arising from a small area of thickened cells on one side of the blastoderm, encloses the yolk and endoderm by a genuine epiboly.[2]

It is, however, with some hesitancy that I expose the following tentative views on the subject, with the hope that, if they do not at present afford an entirely satisfactory and complete explanation of the facts, they may at least help toward the solution of the difficult problems of the origin and significance of the embryonic membranes and the germinal layers in the Arthropoda, and in this way serve, perhaps, to throw some light on the phylogeny of the group.

How did the embryonic membranes (amnion and serosa) arise? What is their function? Is their present function the primitive one? The answer to these inquiries undoubtedly lies in the clear comprehension of the relations of the embryo to its food supply — the yolk. That the cellular embryonic membranes could have originated for protection, or from an early ecdysis is, to say the least, highly improbable. Among the Insecta the egg is furnished with a *protective membrane* — usually in the form or a chorion — before leaving the body of the parent. The presence of an unusually large amount of yolk matter, fundamentally changes the manner of cleavage in the egg of the Arthropod.[3] After the formation of the blastoderm the yolk is inclosed in a cellular membrane which is, strictly speaking, a food sac or stomach: functionally considered it is consequently endodermic, not ectodermic, in its nature. The ectoderm arises, as has been said, in a limited area on one side of the

[1] In most animals the polar corpuscles are formed just at the outer edge of the nuclear membrane and exert an attraction in all directions, through the nuclear substance, producing the spindle phenomenon and through the yolk, producing the astral structures. In some cases (e. g. Limax) they are formed at a distance outside the nuclear membrane and never come in contact with it. There are, then, three positions which the polar corpuscles may assume. They may lie entirely within the nuclear membrane, the latter apparently setting a limit to its influence (e. g. Oecanthus); they may lie in contact with the outer surface of the nuclear membrane and exert their influence through both nuclear and cell substance (e. g. most animals and plants); or they may lie at a distance outside the membrane and influence both nuclear and cell protoplasm (e. g. Limax; see Literature, 30). Since these polar corpuscles are essentially nuclear in their origin the last two cases are to be considered as derivatives of a primitive form, in which the corpuscles are internuclear.

[2] The so-called endoderm, on the other hand, remains throughout its existence an inert mass of food substance between the particles of which numerous *indifferent cells* are found.

[3] In Oecanthus there is no trace of yolk segmentation.

egg, and by a subsequent growth entirely surrounds the endodermic sac and its contents. This process is modified, however, by the interpolation of the so-called embryonic membranes. Since the endodermic sac is so extremely large — as compared with the size of the embryo — that the latter could not easily inclose it by a simple epiboly much before the time of hatching, it is apparent that any modification of the primitive process which will enable the embryo to enclose the yolk earlier will be advantageous to the animal by shortening the developmental processes. Hence, the lateral edges of the band-like embryo instead of epibolizing the yolk have acquired through adaptation the tendency to grow ventrad instead of dorsad, so that on the completion of the amnion, the embryo is developed inside out, with its dorsum (the amnion) covering the ventral surface of the germinal band after the fashion of a membrane.

That the cavity inclosed between the so-called amnion and the germinal band is really external to the embryo is evident from the fact that the external ends of the stomodaeum and proctodaeum communicate with it. The fusion of the two edges of this amnion in the median ventral line, may take place simultaneously with that of the serosa, or it may take place quite independently of the serosa and at a later period. The embryo may, or may not, become entirely disunited from the endodermic sac (now serosa), and hence may be related to it in one of three ways. It may be in contact with, it may be fused with, or it may lie entirely within, the serosal sac. This process is capable of being explained in two ways. Either the yolk mass would not allow the dorsad growth of the lateral edges of the germinal band, or it is strictly an adaptive response of the embryo to changed conditions of environment. The latter is probably the true cause of the unique phenomenon of an animal undergoing development inside out, and its object can only be the swallowing of the food stored up for its nourishment. The amnion and serosa fuse in the head region of the embryo. This fused membrane soon ruptures, so that the sac-like embryo, which up to this has had no structural connection with or control over its food sac, becomes united with the serosa into a double sac, a sac within a sac.

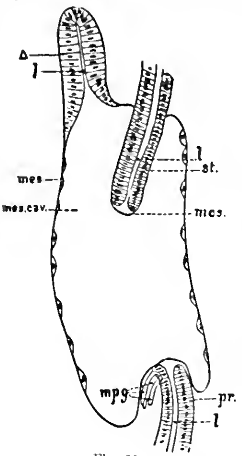


Fig. 29.
Diagrammatic representation of the relations of the mesenteron, stomodaeum, and proctodaeum after the closure of the body walls over the dorsal organ or plug. Compiled from sections of an embryo. ×50.

The embryo now everts itself through this opening and lies outside of the yolk sac, which in the meantime has assumed a position dorsad to the embryo. The amnion now forms the dorsal and part of the pleural walls of the embryo and at its cephalic termination is continuous with the yolk sac. The yolk together with the greater part of the cell elements forming the wall of the yolk sac is soon enclosed within the body of the embryo. The remnant of the yolk sac remains for some time as a plug-like projection from the median dorsal line immediately behind the head, and is the homologue of Kowalevski's dorsal organ.

Since the appearance of Kowalevski's paper on the embryonic development of Hydrophilus, in which he first makes known the existence of a dorsal organ among insects, the conjectures as to its probable significance have been various. The following explanation of its origin and function is a necessary corollary from the previous explanation of the embryonic membranes.

As has already been shown for Oecanthus, the embryonic membranes (especially serosa) finally assume the condition of the dorsal organ of Hydrophilus, with this notable exception: the organ does not extend the entire length of the mesenteron, nor does it possess a distinct lumen, but as the sequel will prove the difference is only one of degree and not of kind.

Briefly reviewing the facts in the two cases, we find that in Hydrophilus there is a fusion of the serosa and amnion and a subsequent rupture of the fused membranes in the median ventral line.[1] Fig. 30.

Fig. 30. Fig. 32.

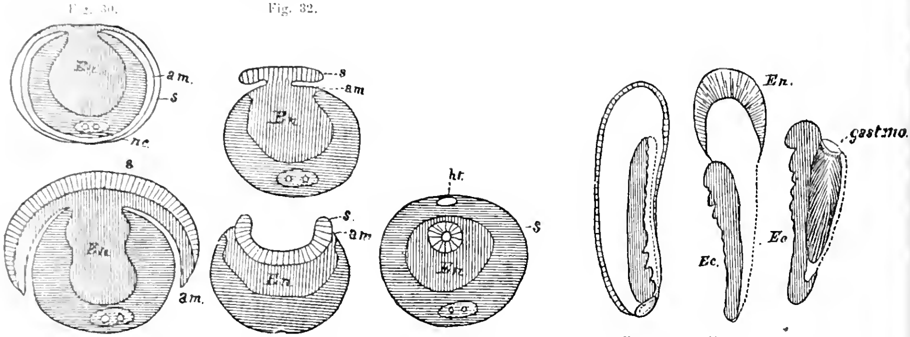


Fig. 31. Fig. 33. Fig. 34. Fig. 35. Fig. 36. Fig. 37.

Figs. 30–34. Diagrammatic illustrations of the formation of Kowalevski's dorsal organ.
Figs. 35–37. Diagrammatic illustrations of the varying relations of the embryo to its yolk sac.

By the contraction of the serosa the amnion is pulled off from the ventral surface of the body (fig. 31) and goes to form the dorsum of the embryo after the serosa has contracted into a thick rod and has passed into the mesenteron. The serosa first forms a thick plate on the dorsum of the embryo (fig. 32 and Kowalevski, 26, pl. 8, figs. 14, 15, 16). This plate is in union with the body wall at its edges, and by the upgrowth of the walls it becomes longitudinally folded on itself forming a tube open at the head end. (Fig. 33.) This end is the last to be covered over by the dorsum. (Fig. 34.) It finally loses its connections with the body walls and undergoes disintegration within the mesenteron.

In Oecanthus the membranes fuse at or near the head, and by a self eversion through the opening caused by their rupture the embryo comes to lie outside of the amnion and serosa. The latter now forms a yolk sac, which by a gradual contraction, as the yolk is absorbed, comes to lie within the body, being last seen just back of the head. (Pl. 19, figs. 1–5, ; pl. 22, figs. 1, 11 ; pl. 23, fig. 2 ; pl. 25, fig. 31.) It is always in connection with the mesenteron and its thick walls finally disappear by a process of disintegration.

Although Brandt (8) makes no mention of the function or fate of the thickened serosal yolk sac which he so frequently figures (loc. cit., pl. 2, figs. 15–22 ; pl. 3, figs. 32, 34, 38), there can be no doubt that it is the same structure that exists in Hydrophilus and Oecanthus.[2]

[1] Kowalevski leaves this point in doubt since he was uncertain as to the fate of the amnion. He states that it is either ruptured or absorbed. From its fate in other insects the former seems more probable than the latter.

[2] Compare also Metschnikoff (32) pl. 23, figs. 15, 19–23; pl. 26, figs. 9–27 ; pl. 27, figs. 20–28 and pl. 30, figs. 29–34.

From these figures it is apparent that in many if not all insects the serosa and amnion play the same rôle that they do in Oecanthus, i. e., the serosa functions as a yolk sac while the amnion is the dorsal wall of the insect. Hence the so-called dorsal organ is but the remnant of the yolk sac.

Note.—In the light of the important discoveries in the embryology of Tracheata made by the late Professor Balfour (F. M. Balfour—The Anatomy and Development of Peripatus Capensis. Quart. Journ. Micr. Sci., n. ser., No. xc, April 1883, pp. 213-259, pl. XIII-XX) the process of gastrulation in Oecanthus is more satisfactorily explained. In Oecanthus the original blastopore or gastrula mouth, existing near the head end of the egg after the formation of the blastoderm, elongates with the formation and growth of the germinal band into the form of a shallow furrow (the so-called mesodermic groove of insects). It does not form, as in Peripatus, a slit-like opening within the limits of the germinal band, the lips of which coalesce in the median line leaving at either extremity of the blastopore an opening into an archenteric cavity—Balfour's so-called mouth and anus,—but the posterior opening begins as a shallow pocket and opens into the archenteron at a very late period. The mesoderm arises in the region of the primitively circular mouth and grows backward, following the course of the groove in the germinal band. The anus consequently is a part of the blastopore while the mouth is a secondary formation. The embryonic mouth persists until near the time of the closure of the body wall over the dorsum.

These views may be stated as follows:—

1. At the close of blastoderm formation the archenteric cavity is completed, and its mouth is on the dorsum of the cephalic region (compare Oniscus, Mysis, Scorpio, Libellula, Calopteryx and Hemiptera parasita), hence the blastoderm equals endoderm, not ectoderm.

2. The ectoderm arises simultaneously with, if not previous to, the endoderm; but, instead of surrounding the entire endoderm, it covers only a small area on the dorsal side in the region of the gastrula mouth. Subsequently, however, it surrounds the archenteron and it also becomes incomplete at the circular gastrula mouth, where it unites with the endoderm.

3. The mesoderm arises before the full completion of the gastrula as an unpaired plate in the region of the fusion of ectoderm and endoderm, i. e., near the lips of the gastrula mouth, and grows both backward and dorsad between the ectodermic and endodermic layers.

4. The so-called mesodermic invagination is to be considered as connected with the blastopore—perhaps in some cases the only indication of the previous existence of a gastrula mouth.

5. On account of the pressure of an unwieldy mass of yolk these processes are somewhat modified, but not so completely as to lose their identity. On this account the completion of the gastrula is retarded until the organs of the embryo are well advanced.

In Scorpio, Mysis, and Oniscus, the blastopore is dorsal in position.

TELEAS.

A parasitic Ichneumon fly, probably of the genus Teleas, infesting the eggs of Oecanthus, presents highly interesting stages of development which were first made known by Metschnikoff in 1866, and were more fully described for Teleas and a number of related forms by Ganin about two years later. The results of my study on Teleas differ in some points from those of Metschnikoff and Ganin on species of the same genus. De Filippi (16) has described the embryonic changes of a Pteromalian, parasitic in the egg of a curculio (Rhynchites), which, to judge from his figures, closely resembles Teleas in its younger larval stage.

Metschinoff (32) gives a short account of the development of a species of Teleas infesting the eggs of Gerris lacustris, of which the following is a brief summary. The earliest observed stage was that of the stalked egg in which the blastoderm (Keimhaut) was already formed. This blastoderm was composed of cells resulting, in his opinion, from a total segmentation of the egg. It surrounded a central cavity which Metschnikoff considers homologous to the segmentation cavity of Copepods and certain Daphnias, and therefore he gives it as his opinion that this cavity existing in Teleas is a genuine segmentation cavity. At the close of segmentation there lies outside the blastoderm a cluster of round cells which later form about the embryo a membrane analogous to the "amnion" (equivalent to the serosa of authors) of other insects. When this membrane is fully formed the embryo is seen to be a round, laterally compressed body. A median furrow now appears causing a division of the embryo into symmetrical halves, the so-called Keimwülste. The embryo elongates and becomes kidney-shaped, the furrowed face remaining convex, the opposite one becoming concave. While the embryo still consists of a single layer of cells, the head region is differentiated, and the continuation of the above mentioned furrow into this region gives rise to two well-marked head folds (Kopflappen). With the further growth of the embryo its head broadens and its posterior end becomes conspicuously narrower. The cells of the dorsal wall become broader and thinner, while those of the ventral wall remain cylindrical and, on the whole, increase in thickness, so that one may now for the first time speak of a germinal band (Keimstreif). With still further development there is formed on the head a transverse fold, the lateral edges of which are especially well marked and are afterwards converted into the pointed jaws, while the median part of the fold is only faintly indicated and finally disappears altogether. The central cavity now becomes filled with small round cells which are derived from the ventral plate and soon form the mesenteron. Invaginations at either end of the embryo form the stomodaeum and proctodaeum. The latter remains unconnected with the mesenteron during the whole of the first larval period. The hind part of the embryo grows rapidly in length, whereby it is considerably narrowed and finally is converted into the long, pointed tail. A muscular system is developed in the embryo, now a larva, and a cuticular covering is secreted about the body. This cuticula is armed with bristles, disposed on both sides the equator of the embryo and they are moved in only one direction by muscles. The embryo now comes out of the "amnion" and feeds on the yolk of the host egg. The germinal stripe remains in the larva as an undifferentiated band of cells from which (but only at a much later period) the ventral portion of the nervous system is formed; whereas the youngest larva is already furnished with a bilobed brain mass. Metschnikoff's endeavors to determine whether an amnion (Deck- or Faltenblatt) was present or wanting proved entirely fruitless.

Ganin (19) studied the development of several genera of the Pteromalidae, among others a species of the genus Teleas. The following is an abstract of his observations on that species. The author takes exceptions to Metschnikoff's view of the existence of a central cavity in the segmented egg of Teleas and, although not having seen the segmentation of the egg in this species, he still believes that it ought to agree closely with Platygaster, Polynema and Ophioneurus, where the result of segmentation is an outer layer of small cells surrounding a solid mass of large "central cells." He goes so far as to say that the production of a segmentation cavity in the egg of Teleas as the result of a total segmentation is, at least for him, inconceivable. Ganin claims that Metschnikoff's observation regarding the origin of the mesenteron is also erroneous, since he believes that it arises from the large "central cells," which at first constitute a solid cylinder, in which a central cavity is afterwards developed. The proctodaeum and stomodaeum arise here, as in the other Pteromalidae, by invaginations of the hypodermic layer at either end of the body. The earliest stage observed by Ganin was what he called the first larval form. It bears a very strong resemblance to the first larva of Platygaster; the cephalo-thoracic portions especially are to be compared. The only internal organ possessed by this larva is a mesenteron which ends blindly behind. Its wall is composed of comparatively large cells, and is destitute of a muscular layer. The cuticular covering of the body is furnished with two sharp, curved jaws, an upper lip (located far back of the mouth opening near the junction of the cephalo-thoracic with the abdominal portion of the body), a tail and two transverse rows of bristles back of the head region, one on each side of the body. These bristles are structureless prolongations of the cuticula and are long enough to reach to the end of the tail. The author observed them in motion but could not distinguish the muscles described by Metschnikoff. The tail is composed of two conjoined parts and diminishes constantly in size with the growth of the larva. On the transition to the second larval stage it disappears. The thin, structureless cuticula is thickest on the head. On the ventral side of the latter is seen the mouth opening, circular in form. It lies in the median line between the jaws and is bordered by a sharp outline. The proctodaeum does not appear in the first larva and the muscular system remains but poorly developed. There are a number of tail- and jaw-muscles. The body cavity contains numerous amoeboid cells, which are believed to be the indifferent embryonic cells left from the central cell mass after the formation of the mesenteron, although in Platygaster similar cells are claimed to arise from the hypodermis. In Teleas the latter is of uniform thickness at all points of the surface. When the first larva passes into the second larval stage the hypodermis in the tail region is invaginated and forms a proctodaeum as in Platygaster. It then thickens along the whole ventral line and forms a germinal band which is continuous posteriorly with the undifferentiated walls of the proctodaeum. This process is the result of a rapid cell proliferation in this region. In the dorsal part of the head region the germinal band curves into a pair of very thick head folds which are separate from each other as well as from the hypodermis of the dorsal region. The folds give rise to the supraoesophageal ganglia. The lateral portions of the germinal stripe furnish the muscular system. Salivary glands appear at first as solid cords of cells derived from the anterior portion of the germinal stripe. They subsequently develop a central lumen, ending blindly behind but opening out in the mouth region. The eggs of Teleas are very small, transparent, and colorless; they possess no yolk.

These are the main facts which the author gives with regard to the development of Teleas, he, however, believes on grounds of relationship and for *a priori* reasons that the development of Teleas corresponds in all essential particulars with the facts obtained in his researches on Platygaster, Ophioneurus, and Polynema. He states that the embryonic membrane which he has called amnion is not homologous with this membrane in other insects but is to be[1] compared with the skin developed on the dorsal side of some low worm-like Acarians (Pentastomum) and the larval skin of crustacean embryos (loc. cit., p. 416).

In order to avoid confusion it will be necessary to observe, that Ganin's first larva of

[1] Packard (35) says: "may possibly be."

Teleas is equivalent to the third stage which I have found parasitic in the eggs of Oecanthus niveus, and is the same as the larva of Metschnikoff; furthermore that Ganin's second larval form is only my "third stage" in process of ecdysis. For an excellent summary of Ganin's entire paper one may consult Balfour (1). Packard has given a more detailed extract in (35) and (36).

The earliest stage[1] of the parasite found in the eggs of Oecanthus was that of the completed blastosphere (pl. 23, figs. 23, 31). This perfectly spherical body consists of a shell of small, short, cylindrical cells which encloses a colorless, finely granular fluid, possibly a nutritive or yolk matter. At this stage there are no cell elements except those which form this shell (Blastoderm of Metschnikoff—Embryonalanlage of Ganin). Soon amoeboid cells are budded off from the inner ends of these cells and make their way into the contained fluid. They are usually much smaller than the cells of the blastosphere and are irregular in form. Some of them appear destitute of any nuclear structure, but most of them possess a small, sharply defined, eccentric nucleus. On one side of the blastosphere the cells in a linear tract elongate causing a spindle-shaped ridge to be formed on the surface. This increases in size until it is quite prominent, when there appears a median furrow dividing it into symmetrical halves or folds. At each end the folds are continuous with each other by means of a narrow, curved cross-fold. The growth of the folds is accompanied over the whole of the inner surface of the blastosphere by a cell proliferation which is most active along the region of the folds or germinal band. There now appear at the starting point of the folds two pairs of prominent thickenings (pl. 23, fig. 27), the head folds. The anterior of these is the larger and ends abruptly in the germinal band. From this point backward the band gradually thickens into an evident prominence (pl. 23, fig. 27) which probably marks the boundary between the thorax and abdomen. It is now bordered on each side by shallow furrows, produced by thickened bands running outside of and parallel to it. The germinal band extends over half the circumference of the blastosphere which now begins to elongate into the spindle-shaped larva. In the meantime the amoeboid cells collect into a mass in the centre of the embryo and form the endoderm. In pl. 24, fig. 1, is shown the relation of the parasite to the host in this stage, while in pl. 23, fig. 35, is shown a cross section of a blastosphere magnified 800 diameters giving the mutual relation of the elements composing it. In the young blastosphere the elements are very small, thin-walled cells with the longest diameter radial to the sphere (pl. 23, fig. 23); as seen from the surface they are polygonal in outline; upon treatment with osmic or acetic acid they become spherical. In the youngest stage following segmentation, they are arranged in a uniform layer with no appreciable difference in the size of the cells; soon, however, the cells in certain tracts begin to increase in size and to proliferate, giving off from their inner ends amoeboid cells which go to form a layer of cells of irregular sizes and shapes just beneath the ectoderm. As soon as proliferation begins, the cells lose their uniformity of arrangement and cohesion, the least pressure being sufficient to displace them. In sections of this stage are found cells of the size and characteristic appearance of ectodermic cells lying just outside the ectodermal layer, although

[1] The egg has not been seen but is probably of the usual pedunculate form, with the colorless yolk not gathered into yolk masses. The segmentation of the egg is total, as the product proves. Allowing the contents of the sphere to be genuine yolk-matter, there is no evidence that the segmentation may not have been "superficial."

in the fresh state no such cells are to be seen. These occur at irregular intervals and are found only when the blastosphere shows traces of having been ruptured by the swelling influence of reagents. (Pl. 23, fig. 35.) In all stages the parasite is surrounded by a mass of clear protoplasmic substance which has been affected by the presence or secretions of the parasite. On sections of the first stage one finds surrounding the blastosphere, but at some distance from it, a thin wall of condensed albuminous matter containing within its substance no indications of cell structure. This layer cannot be made out in the fresh state. It is not found in sections of the two subsequent stages of the parasite. There are no other layers to be found enveloping the parasite in any stage observed.

This stage [1] agrees perfectly with that observed by Metschnikoff in another species of the genus Teleas, with the single exception of the absence in the present case of any cellular embryonic envelope such as both Ganin and Metschnikoff describe for Teleas and other genera of Pteromalidae. Since the segmentation of the egg was not observed in this case, only negative evidence can be produced to prove that *all* the resultant cell elements go to form at first a single-layered blastosphere. It is, however, highly probable that such is the case, since at no stage of the blastosphere can any such elements (i. e. embryonic membranes) be found. Since this is the stage in which the embryonic membranes (i. e. amnion and serosa) are presumably beneficial to the growing embryo, it must be concluded that all such structures are wanting in this particular case. I hesitate to apply these conclusions to any other forms of the Pteromalidae, for the observations of Metschnikoff and Ganin clearly prove that these forms differ greatly among themselves in the particulars of their embryonic development, though bearing very strong resemblances to each other in their older larval and adult states. We have in this form, then, an insect which has no trace of embryonic membranes such as are found in all other insects. Here also is a case in which no invagination takes place to form the mesoderm as is held to be true for most insects. This is the more significant since there is no excess of yolk matter to hinder the process. The facts obtained from the study of this parasite respecting the origin of the mesoderm should not lead to a misinterpretation of the process. For although the conditions favoring its origin by the typical process of invagination (a blastosphere filled with fluid) are realized, yet in this particular instance it is to be viewed not as a primitive but rather as a secondary method acquired in ancestors where an accumulation of nutritive yolk substance induced a modification of the primitive process, — a modification which has been retained although the conditions which led to it have ceased to exist. The key to this interpretation is to be found in the fact that the eggs of the non-parasitic Hymenoptera are supplied with an abundance of food material, and in such cases the mesoderm arises in a manner approaching the typical invaginate form. The loss of nutritive yolk in the eggs of the degraded forms is evidently correlated with their parasitic habits.

The first differentiation of the blastoderm begins as a linear thickening of the embryonic area (germinal band of other insects), and is followed by the formation of a median groove (Primitivfurche) which divides it into lateral ridges (Primitivwülste). The mesoderm and endoderm are derived from the ectoderm by a process of cell budding which resembles typical delamination in that it takes place from all portions of the inner surface of the

[1] In the figures the outer boundary of the protoplasmi mass surrounding the parasite is indicated by a line. In some figures the adjacent yolk globules are sketched in.

blastosphere, and invagination in so far as it takes place most actively in a region which in other insects is the invaginated tract. It may be said further that the mesoderm and endoderm are at first undifferentiated, since they have the same origin and are to be distinguished from each other only at a much later period. (Compare Metschnikoff and Ganin, loc. cit.)

The elongated embryo is now crescentic in shape with an anterior, oral or cephalic, end and a posterior, abdominal region. (Pl. 24, figs. 2, 8, 9, 13, 14.) The former is the larger while the latter is much smaller and tapers gradually to a point. The region of greatest thickness lies about one-fourth of the distance from the anterior toward the posterior end of the body. Soon after the embryo assumes its crescentic form it secretes about itself a thin, colorless, transparent cuticula, which (in specimens treated with reagents) projects in front beyond the cell mass into a frontal process, and a little behind this on the ventral side into a decided prominence, which bears at its apex the mouth opening. The cuticula of the free edges of the oral opening is thickened to form four crescentic chitinous mandibles. Posteriorly the cuticula is extended beyond the body mass to form a long, tapering, more or less curved caudal appendage. The mesenteron at first ends blindly in front as well as behind, but by coalescing with the invagination of the stomodaeum it soon comes to open out through the mouth. The muscular system of the first larva consists of oral, cephalo-thoracic, and abdominal muscles. The oral muscles are four in number arranged in two pairs. Of these the lateral pairs are much the larger. (Pl. 24, fig. 6.) The shape and size of the muscles vary much in the same larval stage. The oral muscles are fan-shaped and at their smaller ends are inserted in the thickened bases of the mandibles, from which they extend out to their origin in the lateral and ventral body walls. A cephalo-thoracic flexor[1] and abdominal segmental muscles form the greater part of the muscular system of this larva. Some of the abdominal muscles extend into the tail region giving great flexibility to this organ at its junction with the abdomen. The number of body segments occurring in this stage varies in different larvae. The maximum number observed is eight, but the usual number is five. The cuticula is thickest in the head region; here it is seen in optical section, with a magnifying power of 600 diameters, as a double-outlined layer, very distinct anteriorly but gradually merging into a single line in the abdominal region. In the equator of each segment the cuticula is produced into numerous, finely pointed, hollow bristles, the lumen of each of which is at least partly filled with a finely granular protoplasm which contains a nucleus situated opposite the mouth of the lumen. On the ventral side of the base of the caudal appendage there are to be seen a varying number of hollow tooth-like projections[2] of the cuticula also filled with a finely granular protoplasm. The caudal appendage ends bluntly, and its terminal fourth is covered by numerous fine bristles which are somewhat restricted to its dorsal surface This appendage, like the teeth at its base and the frontal lobe, is filled in the living animal with a granular protoplasm containing few if any nuclear elements. The hypodermis, which lies immediately under

[1] There is probably an extensor also, but this latter was not observed, although motions of the larva were seen which could only have been executed by the action of such a muscle.

[2] One peculiar larva was observed (pl. 24, fig. 12) in which, besides the bristles upon each segment, there were three large spine-like projections of the cuticula resembling the caudal appendage. They arose respectively from the cuticula of the dorsum of the head, of the thorax, and from the ventral side of the abdomen just above the base of the caudal appendage.

the cuticula which it has secreted, is at this time very thick, but as the embryo increases in size it becomes proportionately somewhat thinner and differentiated into a "ventral stripe." Subsequently there is separated from the posterior end of the ventral stripe a mass of cells which comes to lie dorsad to the stripe and posterior to the mesenteron, to which latter it is intimately connected. Lying on either side of the mesenteron but connected with its walls are seen two elongated sacs (pl. 24, figs. 9, 11) terminating blindly at both ends, which may be in some way related to the salivary glands of the second larva. The motions of this larva are in the plane determined by the longitudinal and dorso-ventral axes of the body, with the single exception of the lateral pair of mandibles, which move at right angles to this plane. Immediately posterior to the mouth opening are seen (pl. 24, fig. 6) two roughened patches of the cuticula which will be seen further developed in the second larva. The larva changes its position in the yolk by movements of the rows of bristles after the manner of fins, by the flexion of the tail, and by bending the entire body. Upon straightening out after having thus flexed itself, it is propelled into new feeding grounds. At this stage the food consists of the yellow fat globules of the yolk. The colorless amoeboid cells and albuminoid masses seem to remain undisturbed by the parasite. In the act of deglutition the whole enteric cavity is thrown into a series of contractions and peristaltic movements, although no muscular elements are to be detected in the wall of the mesenteron.

Fig. 38. Fig. 39.

Fig. 38. Side view of caudal spines showing graded variations in the number and position of the stout basal spines. × 125.

Fig. 39. Two bristles from the dorsum of the same individual. They appear filled with a granular protoplasm. Osmic acid preparation. × 500.

The second larval stage is characterized by the peculiar form of the body, which strongly resembles the cyclops larva of Ganin; it is indeed equivalent to this stage in the scale of development. It is mainly distinguished from the previous stage by the presence of two hooked mandibles and a complicated apparatus functioning as lower lip. The changes occurring in the spindle-shaped larva during the period of transition into the cyclops form have not been observed; however, I have not the slightest doubt that the latter is but the former in a later stage of development. In a series of Oecanthus eggs taken from the same elder stem, eighteen out of twenty-five were infested with the parasite. Several of these contained the three stages that I have described as belonging to one species of Teleas, a greater number enclosed both the cylindrical and the cyclops forms, but by far the majority of the eggs contained two or more cyclops larvae. In those eggs in which the cylindrical larva is found, I have never observed more than one cyclops larva. These facts indicate that the ova of the parasite had been deposited in varying numbers in the eggs of Oecanthus and that of the forms developed from these, some were retarded in their growth.

In this stage the cuticular secretion is highly differentiated, the complications of its structure increasing with each ecdysis. During the period of transition from the first to the second larval stages, the form of the body undergoes such marked changes that the latter bears but little resemblance to the spindle-shaped larva. The cyclops larva is about 0.5 m.m. in length. Pl. 24, figs. 19–23, and pl. 25, figs. 1, 7, give one a clearer conception of its form than any brief description would serve to do. In this stage the cuticula extends over the larva as an unbroken sheet, except at the mouth opening; here it is wanting in a circular area, the external opening of the stomodaeum. It projects forward from the forehead to form a sheath for the antennae, at the bases of which it is thin and flexible, allowing slight movements of the organ. (Pl. 25, fig. 19.) Below the antennae on the ventral surface the mandibles are formed as scythe-shaped, pointed, tubular projections of the cuticula, which grows gradually thicker and yellowish toward the tips, where it shows the characteristic color of chitin. Here, also, as in the antennae, the cuticula thins out at the base of the organs, allowing great freedom of motion to the mandibles. Below these the cuticula is thrown into a double-layered fold which varies in its structure with the degree of development of the larva. For successive stages of this fold, or under lip, see pl. 24, figs. 17, 19, 20, 21, 24. As will be seen from these figures, the lip is at first a simple projection, later becoming bent up at the tip. Sometimes it presents lateral grooves for the reception of the tip of the mandibles, thereby increasing their efficiency in cutting the yolk mass of the host into bits suitable for swallowing. The lip sometimes strongly resembles the lower mandible of a hawk or an owl. It may be bifid but its upper surface is always concave. One larva was found in which the mouth was kidney-shaped and the lip proper extended as a gutter from a point on each side of this opening downwards, and outwards, the edges gradually converging in an up-turned, sharply pointed tip. This fold was only a part of a larger lip-fold extending to, and losing itself in, the lateral boundaries of the body wall posterior to the lip proper. Beneath this was a broad fold which united with the body midway between the primary and the secondary lips. This fold seemed to function as a support to the lip as well as a scoop to aid the larva in feeding. There is a pair of cuticular structures of a problematical nature, usually one on each side of the body between the mandibles and the lower lip, but varying considerably in their relative positions in different larvae. (Compare pl. 24, figs. 17, 19, 20; pl. 25, figs. 1 and 6.) They vary greatly in structure but each usually consists of a cup-like depression in the cuticle in which there are secondary cup-like depressions. The cup may be rendered imperfect by the extension into its area of a narrow band of the smooth cuticula. The secondary cups may present a simple outline or may be irregular in shape and separated from each other by a band-like margin. These structures assume a more lateral position as the nervous system increases in its development, and as they lie at all times on either side of the suboesophageal ganglion they may function as sense organs. No direct connection between these structures and the nervous cord could be traced. Posterior to the structures just described there is a thickened fold of the cuticula most prominent in the median dorsal line, which gradually lessens until it finally disappears in the lateral walls of the body. This fold forms a boundary line between two distinct regions of the body, the cephalic and the abdominal. It serves to strengthen the cuticular walls of the cephalic region, and like all other cuticular

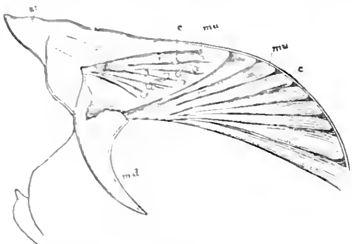


Fig. 40.
The mandible and antenna of the left side of the body of the larva figured in pl. 24, fig. 20. The surfaces of the mandibular muscles are shown. × about 500.

structures varies greatly in its relative position with the degree of the development of the larva. It forms the border of a deep groove which indicates the anterior limit of the abdominal region. From this groove the abdominal wall gradually swells out into a flask-shaped body, which carries in front of its equator a pair of lateral flattened expansions of the cuticula, filled with hypodermic cells. These bodies are the fin-pads. On their dorsal surface one finds numerous small dentate papillae, while from their margins and outer portions are given off from 15 to 30 long, curved, unjointed, hollow, colorless bristles. These fin-pads are moved in a plane at right angles to the dorso-ventral axis of the body by several well developed muscles. The tip of the abdomen, which is not terminal in position but lies on the ventral surface of the body, is continued into a long, hollow, cylindrical appendage, usually terminating in a dentate knob (pl. 24, fig. 18), the teeth of which are on its ventral side. When the larva is quiet the terminal end of the caudal appendage lies opposite the mouth, and when the larva feeds it serves both to break up the yolk and to shove it into the spoon-shaped lower lip.

When the larva is about to enter upon an ecdysis the cell structures become dark from the presence of granules in the protoplasm, the hypodermis shrinks away from the cuticula, the walls of the mesenteron shorten and thicken, the muscles lose their striate appearance, the protoplasmic contents of the antennae, mandibles, and caudal appendage recede from their sheaths and together with the hypodermic cells of the fin-pads are drawn into the body mass. The cuticula now swells and loses its definite shape and ultimately becomes a thin sac loosely enveloping the larva. The cells of the hypodermis next secrete a new cuticula and the larva at once assumes its former activity, rupturing the cast off cuticula and burying itself again in the yolk matter of its host.

Fig. 41. Surface view of the hypodermis of the third larva. × 125.

While the spindle-shaped larva is changing into the mandibulate form, the cell elements of the body lose their distinctive characters so entirely that the slightly differentiated organs are scarcely to be distinguished in the cell mass. As soon as a cuticula is secreted, however, the relations of the cell groups become distinct and now for the first time the muscular fibres of the abdomen are to be seen. There is, then, a histolysis of the cell groups but no cell-fusion or cytolysis. The muscular system of the second larval stage consists of thirteen paired and two median unpaired muscles. The largest muscles of the body are the mandibular adductors, while their corresponding abductors are the smallest ones present in the body at this time. These four muscles which almost fill the cavity of the cephalo-thorax are pyramidal in form and have their origin in the dorsal wall of the cephalo-thorax and their insertion into the upper and lower rami of the mandible of the right and left sides respectively. When fully extended the mandibles project at right angles from the body, but when completely retracted they lie in close contact with the body wall, their tips fitting into the lower lip. There are two pairs of dorsal muscles connecting the head and thorax. The more superficial extends lengthwise the body (pl. 24, fig. 22) while the deeper pair extends somewhat obliquely to this axis. The large abductor of the fin extends at right angles to the longitudinal axis of the body, following the dorsal half of the equator of the abdomen to its origin in the hypodermis of either side. Two other fin muscles extend obliquely from this organ backward toward the median line, in the hypodermis of which they take their origin. The insertion of all the fin-muscles is in the hypodermic cells of the pad. In the median dorsal line of the abdomen, in a plane parallel with the dorsal fin muscle, is a band-shaped muscle which serves to flex the abdomen towards the head. The remaining muscles are smaller than those mentioned above and without exception are confined to the abdominal region. In pl. 24, fig. 26, are shown four abdominal muscles which, when viewed from behind, form a rectangular figure about the mesenteron. Pl. 25, fig. 10, is a transverse section showing the adductor of the mandible near its posterior margin and its manner of origin and insertion. The striated appearance of the muscle fibres is shown in pl. 24, fig. 28. Pl. 25, fig. 12, illustrates the manner in which the abdominal muscles are inserted into the body wall.

As has been stated, the alimentary tract of the first larva became indistinguishable from the surrounding cell mass as the larva passed into the second stage, but already the stomodaeum had opened into the mesenteron so that at the beginning of this stage the larva is furnished with as complete an enteric cavity as is present in many insects that are not degraded by parasitism (e. g. carnivorous larvae of Myrmeleon etc.), and there is a resemblance between such larvae and the second larva of Teleas which is even more than superficial. The enteric cavity consists of a blind sac in the course of which there are two enlargements, one terminal, the other (pl. 24, figs. 23 and 25), near the suboesophageal ganglion and probably near the point of union of the stomodaeum and mesenteron. If this conjecture is correct, this enlargement is homologous with the proventriculus of other insects. This second enlargement is not always sharply limited. The enteric sac is a cellular membrane (pl. 24, figs. 23, 25; pl. 25, figs. 1, 7, 8, 17) in which the large, polygonal, thin-walled cells are closely united; each cell contains a spherical nucleus, central in position, with a varying number of nucleoli, one of which is much larger than the others. The mesenteron or abdominal portion of this enteric cavity is retained in its place by protoplasmic filaments which reach out and coalesce with similar processes from the hypodermic and muscle cells, pl. 25, fig. 1. No muscular fibres are to be distinguished in the enteric tract, but contractile motions are sometimes seen, especially in the anterior portion. The oesophagus, after passing through the space between the large mandibular muscles and the circum-oesophageal ring of the nervous cord, passes into a depression of the ventral surface which is continuous with the furrow in the anterior face of the lower lip. (Pl. 25, fig. 19.) Sections through the thoracic and abdominal regions (pl. 25, figs. 10, 11, 13, 14, 17) show that the cells of the mesenteron are closely connected with the hypodermal layer and the ventral stripe, but that later the enteric tract becomes entirely separated and is joined to them only by the protoplasmic filaments. The proctodaeum arises as an invagination in intimate connection with the posterior end of the abdominal nerve plate. The hypodermis, which, like the enteric tract, is a single-layered sheet of cells more or less fused together, lies in close contact with the inner surface of the cuticula and in its primitive condition is a syncytium, the protoplasm of which is finely granular and contains nucleolated nuclei. Subsequently walls appear about all these nuclei thus forming the polygonal cells of the hypodermis. It is probably while in the syncytial condition that the cuticula is secreted, since there is no trace of the outlines of the cells such as would probably appear on the inner surface of the layer if such cell walls existed. The hypodermal cells are of about the same size as the cells of the mesenteron. This layer at its posterior termination opens into the cavity of the caudal appendage so that the protoplasmic fluids of the body cavity can pass freely into the lumen of this appendage. The salivary glands were not detected in any of the living parasites, but on transverse sections of this stage they are found in various degrees of development. They arise as solid rods of mesodermic elements in which a small but gradually increasing lumen early makes its appearance. (Pl. 25, fig. 17.) These rods are derived from the lateral edges of the ventral stripe, and lie one on each side of the incompletely developed nervous cord, which at this time they approximate in size.

At the beginning of this stage the ventral stripe was seen in its primitive state as a layer of enlarged hypodermal cells along the median ventral line. These cells, together with the mesodermic elements, soon form by a rapid proliferation a thick, ventral cell plate or bed. The derivatives of the hypodermal cells are from this time on to be distinguished from the mesodermic elements. The hypodermal cord is more and more differentiated, until it becomes sharply defined from the surrounding mesoderm. It exhibits an enlargement at each end, and at one-third of the distance from the cephalic end a less conspicuous swelling, while between this latter and the head end it forms a ring around the oesophagus. The cephalic termination is the primitive brain mass. (Pl. 25, figs. 9, 19; pl. 24, figs. 23, 25.) The abdominal enlargement consists of the last abdominal ganglion and the sexual cells, and is in close connection with the proctodaeum. The middle enlargement is the suboesophageal ganglion and lies in the depression formed by the folds of the lower lip, only a short distance behind the oesophageal ring. The brain mass consists of a cortical layer of spindle-shaped cells with their long axes arranged in a manner radial to the centre of the mass. The central portion of the brain region in pl. 24, fig. 23, represents a surface view of these elongated cells, which consequently appear round. The central mass is composed of small, irregularly disposed, and frequently ill-defined cells. The brain varies much in shape even in individuals of the same degree of development; it may be oval or quadrangular on side view, and its dorso-ventral axis is usually greater than its longitudinal. It is continuous on its ventral face with the nervous cord, which divides soon after leaving the brain to form the oesophageal commissure. The commissural cords unite soon after passing the oesophagus and enlarge into the suboesophageal ganglion. (Pl. 24, figs. 23, 25; pl. 25, figs. 18, 19.) The latter is circular in transverse section, long oval in longitudinal section. It lies between the cup-shaped cuticular structures, and in the cavity formed between the folds of the lip. From this ganglion the cord extends along the curved outline of the ventral wall of the body and enlarges into a pyriform mass which near its middle point is curved upwards around the end of the mesenteron. From the upcurved end of this fold the germs of the sexual organs are budded off as a varying number of cells (2 — 6) imbedded in a homogeneous protoplasm. They appear in sections of hardened specimens as though formed endogenously within the substance of the still persisting mother cells. (Pl. 25, fig. 11.) In pl. 25, fig. 13, is shown a section of one of the primitive sexual masses. The section passes through three cells of similar size. One of these shows within its cell wall two spherical *cells*, within which is contained all the protoplasm of the mother cell. These derivative cells have definite cell walls and a distinct nucleus, indicating their origin by endogeneous cell formation. The different shapes of the sexual germs are seen by comparing pl. 24, figs. 21, 23, 25, 26, 30, and pl. 25, figs. 1-5, 11, 13, 16, 18. During this stage they become entirely separated from the nervous cord, but are connected to the blind end of the mesenteron by protoplasmic filaments, usually one to each mother cell. The invagination of the proctodaeum, the walls of which are intimately connected with this mass, was not very satisfactorily made out, since its lumen can only rarely be observed (pl. 25, fig. 13), and never with the distinctness shown in Ganin's figures of Platygaster. The size of the nerve cord connecting the posterior enlargement with the suboesophageal ganglion varies much in different individuals, the abdominal portion being sometimes of the same diameter as the latter. The cells forming the cortical layer of the abdominal enlargement possess the same characters as the cells of the corresponding layer of the brain mass. The posterior enlargement is usually lobed; bi- and trilobed forms being of most frequent occurrence. Nothing that could be interpreted as peripheral nerve fibres has as yet been differentiated, but the protoplasmic filaments which throughout the body are stretched between the mesenteron and body wall may possibly serve to transmit the nervous impulses to the muscles and to the cells of the enteric tract. No nuclei could be distinguished in these protoplasmic filaments, so common throughout the body, and their contractile nature was not determined with certainty.

This stage closes the history of the development of the parasite up to date (April 1st). I have not as yet observed the ovate, flattened form which succeeds the cyclops stage in the development of other species of the Pteromalidae, but specimens which were apparently approaching this stage were found in two instances. This was indicated by their greater flatness and the proportionate increase in the size of the abdominal over that of the head region. The abdominal region in this stage exhibits no traces of division into segments. The number of ecdyses is unknown. There are at least four, but how many more there may be it is impossible to state.

Explanation of the Plates.

The following letters are used consistently in explaining the figures of Oecanthus and Teleas.

A.
- *ab.* abdomen.
- *ab.c.* abdominal constriction.
- *abp.* first abdominal appendage.
- *a.c.* amoeboid cells.
- *ad.* corpus adiposum.
- *alb.* albuminoid body.
- *am.* amnion.
- *an.* anus.
- *ap.* appendage.
- *a.s.* anal stylet.
- *at.* antenna.
- *at.l.* antennal lobe.

B.
- *B.* brain.
- *b.* body wall.
- *b.c.* body cavity.
- *b.cp.* blood corpuscle.
- *b.f.* brain fold.
- *bl.* blastoderm.
- *b.s.* blood sinus.

C.
- *c.* cuticula.
- *ca.* cavity.
- *c.ap.* caudal appendage.
- *c.b.* cell wall.
- *c.c.* cross commissure.
- *ce.* cell.
- *ch.* chorion.
- *cl.* claw (onychium).
- *cp.* corpus luteum.
- *cp.th.* cephalo-thorax.

D.
- *d.* corpuscle.
- *do.* dorsal.

E.
- *e.* eye.
- *ec.* ectoderm.
- *ef.* "Endfaden," terminal filament, germarium.
- *en.* endoderm.
- *ep.* epithelium.
- *e.pg.* eye pigment spot.

F.
- *f.* foot.
- *f.c.* fat cells.
- *fd.* fold.
- *fg.* flagellum.
- *f.h.* forehead.
- *f.m.* false membrane.
- *f.o.* fin organ.
- *fr.nl.* free nucleus.
- *fs.* facets.

G.
- *g.* ganglion.
- *g.a.* genital armature.
- *g.b.* germinal band.
- *g.c.* germinal (sexual) cell.
- *g.ce.* ganglionic cell.
- *g.p.* granular protoplasm.
- *gr.* groove.
- *g.v.* germinative vesicle, egg nucleus.
- *g.z.* granular zone.

H.
- *h.* head.
- *h.g.* head groove.
- *ht.* heart, dorsal vessel.
- *hy.* hypodermis.

I.
- *id.* indifferent protoplasmic substance.
- *in.* median invaginated part of the nervous system.

K.
- *kf.* head fold (Kopflappen).

L.
- *l.* lumen (in Teleas, lip).
- *lb.* lobe.
- *l.c.* longitudinal commissure.
- *l.f.* lateral furrow.
- *l.fd.* lateral fold.
- *lig.* ligament.
- *lp.f.* lip furrow.

M.
- *M.* mesoderm.
- *m.* micropylar apparatus or end.
- *m¹.* first maxilla.
- *m².* second maxilla.
- *m¹.p.* m¹ palpus.
- *m².p.* m² palpus.
- *md.* mandible.
- *mes.* mesenteron.
- *m.f.* median furrow.
- *mo.* mouth.
- *m.p.* median partition.
- *mpg.* Malpighian tube.
- *m.s.* median cord of nervous system (Mittelstrang).
- *mt.* mesentery.
- *mu.* muscle.

N.
- *n.* nerve.
- *n.c.* nerve cord.
- *nl.* nucleus.
- *nl¹.* nucleolus.
- *nl.f* nuclear fibres.
- *nl.fl* nuclear fluid.
- *nl.m.* nuclear membrane.
- *nl.n.* nuclear nodules.
- *nl.p.* nuclear plate.
- *nl.s.* nuclear substance.

O.
- *o.* ovariole or, pl. 18, head cavity.
- *o.c.* ovarian or egg chamber.
- *oe.* oesophagus.
- *oe.c.* oesophageal commissure.
- *oe.in.* oesophageal invagination.
- *o.l.* optic lobe.
- *o.n.* ocellar nerve.
- *ov.* ovum.

P.
- *p.* polar corpuscle.
- *p.a.* polar aster.
- *p.c.* cheek pad.
- *pe.v.* peritoneal vessel or sinus.
- *p.f.* primitive furrow.
- *p.fd* primitive fold.
- *p.fd.a.* primitive abdominal fold.
- *p.fd.m.* primitive maxillary fold.
- *p.fd.t.* primitive thoracic fold.
- *pig.* pigment bodies.
- *pr.* proctodaeum.
- *prov.* proventriculus.
- *ps.* pseudopodia; protoplasmic filaments.
- *pt.* partition.
- *pt.e.* epithelial partition.

R.
- *r.* rectum.
- *r.f.* radiating fibres.

S.
- *s.* serosa.
- *sc.* scales.
- *seg.* segment.
- *s.g.* salivary gland.
- *s.i.* intercellular space.
- *sk.* invagination of ectoderm to form head skeleton.
- *so.m.* somatic mesoderm.
- *sp.* space.
- *spd.* spindle.
- *sp.f.* spindle fibres.
- *sp.m.* splanchnic mesoderm.
- *s.s.* lateral cords of the nervous system (Seitenstränge).
- *st.* stomodaeum.
- *sub.* suboesophageal ganglion.

T.
- *T¹.*, *T².*, *T³.* first, second, and third thoracic appendages.
- *t.* tunica propria.
- *ta.* tail.
- *t.b.* tail body.
- *t.c.* thoracic constriction.
- *t.f.* tail fold.
- *th.* thorax.
- *ti.* tip of abdomen.
- *tr.* tracheae.
- *tr.f.* transverse furrow.

U.
- *u.l.* upper lip.

V.
- *v.* vacuole.
- *ve.* ventral.
- *vt.* vitellarium, chambered part of the ovariole.

Y.
- *yl.* yolk.
- *yl.m.* membrane of yolk sac.
- *yl.s.* yolk sac.

ν. primitive unpaired organ (metastomum).
Δ. dorsal organ.
λ. pleural structure (gill-pad).
μ. cup-shaped organ.

PLATE XVIII.

Fig. 1. The youngest observed germinal band of Oecanthus niveus. The serosa is not yet formed. × 25. (The *egg* is magnified only 15 diameters.)

Fig. 2. Longitudinal optical section (diagrammatic) of fig. 1.

Fig. 3. The germinal band after the appearance of the head fold, which is indicated at this time by the more rapid growth and consequent greater breadth of the lower end of the embryo. × 25.

Fig. 4. A young embryo of Oecanthus after the appearance of the primitive segment folds. × 50.

Fig. 5. A more advanced embryo, with the antennal folds distinctly marked off. The free ends of the primitive folds have united across the embryo posterior to the antennal folds. × 50.

Fig. 6. Deep, or primitively head, end of the egg after the formation of the serosa. × 25.

Fig. 7. Upper lip and antenna of a somewhat older embryo. × 100.

Figs. 8, 9. Ventral and side views of the embryo with the appendages sprouting out. × 25. In its natural conditions the embryo, having reached this stage of development, remains dormant for six months on account of the cold of winter.

Fig. 10. Ventral view of the tip of the abdomen of the stage figured in fig. 13. The large cells of the amnion cover part of the embryo. × 50.

Fig. 11. Ventral view of another embryo. Acetic acid carmine preparation. × 50.

Figs. 12, 13. Lateral and ventral views of an embryo more advanced than that shown in figs. 8 and 11. × 50.

Fig 14. Camera outline of the head region of the stage represented in fig. 11. Shading diagrammatic. ×125.

Fig. 15. Head of an embryo, somewhat older than fig. 8, in which the invagination at the base of the antennae to form the internal skeleton of the head is well advanced. Acetic acid, carmine, glycerine preparation. × 125.

Fig. 16. A portion of the oesophagus near the mouth showing the salivary ducts united into a common tube. × 65.

Figs. 17, 19. Ventral views of two embryos of nearly the same age. Chromic acid preparations. × 50.

Fig. 18. Side view of another embryo of about this stage. × 65.

Fig. 20. An embryo with the abdominal flexures straightened out. Chromic acid preparation. × 50.

Fig. 21. The appearance of the embryo in ventral view just before revolution. Sodium chloride preparation. × 50.

Fig. 22. An embryo in which the lobation of the mouth parts has begun. The abdominal region is curved upon itself while the proctodaeum forms another curve, projecting into the yolk. The amnion extends as far as the anal stylets. Osmic acid preparation. × 65.

Fig. 23. Lateral view of the head, maxillary and thoracic regions of another embryo of about this stage. Chromic acid preparation. × 75.

Fig. 24. Optical section of an embryo with three folds of the ectoderm projecting into the head cavity These thickenings lie at different depths, respectively 0, 1, 2. × 75.

Fig. 25. Dorsal view of the end of the abdomen of an individual showing the projecting tips of the a. s × 50.

Fig. 26. An oblique dorsal view of the proctodaeum of a younger individual. × 50.

Fig. 27. Ventral view of the abdomen and proctodaeum of an embryo. × 75.

Fig. 28. The "gill-pad" structure, λ, highly magnified; partly diagrammatic. × 225.

Fig. 29. Optical section of the end of the abdomen and proctodaeum of an embryo before revolution. × 65.

Fig. 30. The tips of a foot and an antenna, showing the cuticula as a loose sac enclosing the appendage. × 50.

PLATE XIX.

Fig. 1. Dorsal view of an embryo showing the relations of the "gill pads," *g*, to the body. × 50.

Figs. 2, 3. Lateral and ventral views, respectively, of the same embryo *in situ*. × 50. The embryo has almost completed its revolution. The abdominal flexures have disappeared so that the proctodaeum now projects into the yolk and lies dorsad to the nervous cord.

Fig. 4. An embryo in which the yolk has all passed into the mesenteron. The remains of the yolk sac (serosa) are seen as a plug-like cylinder, continuous with the mesenteron but still projecting beyond the region of the body wall. The stomodaeum and proctodaeum have united with the mesenteron. The Malpighian tubes are sprouting out from the proctodaeum. The "gill-pads" have disappeared; the thoracic appendages and the mouth parts are confined to the now much narrower ventral area. × 50.

Fig. 5. An embryo, some time after revolution, in which the mesoderm plates have coalesced in the median dorsal line. The opening into the yolk sac is much reduced. × 50.

Fig. 6. Frontal view of the lobes of the brain, which are not yet united. From an embryo in clove oil. × 50.

Fig. 7. Frontal view of the mouth parts (labrum, first and second maxillae, — the mandibles lie beneath the maxillae) after the closure of the dorsal wall. × 65.

Fig. 8. The mouth parts of another individual near this stage, dissected out to show the lobes of the first and second maxillae. × 65.

Fig. 9. The three thoracic ganglia dissected from an embryo at this stage. Acetic-acid carmine, balsam preparation. × 400. The cross commissures in the lower ganglion are filled in from another specimen,

Fig 10. Frontal view of the brain and suboesophageal ganglion *in situ*, showing their connection by the commissural cords. From an embryo treated with osmic acid, picro-carmine, clove oil, balsam. × 125.

Fig. 11. Optical section of the germinal band of Oecanthus in the sagittal plane, showing the relations of the cells in the free state. × 560.

Fig. 12. The corpus adiposum and pigment bodies of the right half of one of the abdominal segments of the embryo fig. 1. × 125.

Fig. 13. The free end of the stomodaeum after its lumen has opened into the mesenteron, to show its structure. The epithelial layer is thrown into six folds, while the muscular layer surrounds this thickest portion by a very thin layer of cells. × 400.

Fig. 14. A portion of the antenna of an embryo after hatching showing the spines as cuticular outgrowths, one to each cell. × 125.

Fig. 15. Dorsal aspect of the left anal stylet from the same embryo with its balloon-shaped organ and the hairs. × 65.

Fig. 16. The balloon organ from the above, showing its peduncle. × 100.

Fig. 17. A ventral view of the embryo at the time of revolution, the gill-pad should have been repreented as though seen through the body. × 65.

PLATE XX.

Fig. 1. Oecanthus. An ovariole dissected in osmic acid, stained in picro-carmine. × 160.

Figs. 2 and 3. Ovarioles of Oecanthus prepared in sodium chloride, glycerine. × 160.

Fig. 4. A follicle of Oecanthus from a sodium chloride, picro-carmine, glycerine preparation. × 85.

Fig. 5. The upper end of an ovariole of Periplaneta sp. from a dissection in osmic-acetic solution, hardened in alcohol; balsam preparation. × 400.

Fig. 6. An ovum from the same. × 800.

Fig. 7–10. Four consecutive stages in the revolution of the embryo. × 15.

I. At the time of the fusion and rupture of the serosa and amnion.

II. After the head of the embryo has passed through the rupture.

III. The body of the embryo lies curved in the bottom of the egg; the abdominal flexure still persists. The amnion covers only the latter part.

IV. The embryo has completed the revolution, and the serosa has contracted into a thick-walled sac, but has not changed its position. The amnion has turned inside out and now forms the dorsal and part of the lateral walls of the embryo. The proctodaeum and stomodaeum are enclosed between the dorsa and ventral body-walls. The embryo is now head uppermost and faces in the opposite direction to what it did before revolution. It requires about 24 hours with a temperature of 70° F. to accomplish the change.

Fig. 11. Micropylar end of the living egg in its natural condition. × 125.

Fig. 12. Germinative vesicle of Oecanthus in which the nuclear membrane has been ruptured by the dissecting needle. From an acetic acid, glycerine preparation. × 560.

Fig. 13. Surface view of the follicular epithelium of an ovariole of Acheta prepared in silver nitrate. × 560.

Figs. 14-17. Surface views of the follicular epithelium of an ovariole of Oecanthus, from successive follicles, illustrating yolk formation by nuclear degeneration. × 560.

Fig. 18. Segment of a section of an ovariole of Acheta abbreviata. Prepared in gold chloride, glycerine. × 560.

Fig 19. Nuclei in process of division from the follicular epithelium of Acheta. The ovariole was prepared in gold chloride, alcohol, balsam. × 560.

Fig. 20. Follicular epithelium from an ovariole of Acheta abbreviata prepared in gold chloride and glycerine. × 300.

Fig. 21. Optical section of the membranes of a fresh egg; 0, blastoderm; 1, vitelline membrane; 2, inner-chorion; 3, outer-chorion. × 400.

Fig. 22. Frontal view of the brain *in situ*, showing the outgrowing nerves. × 50.

Fig. 23. Lateral view of one of the lobes. From an embryo in clove oil. × 50.

Fig. 24. Optical longitudinal section of the antenna of a young embryo showing the median mesodermic partition.

Fig. 25. Longitudinal section of the terminal filament, or germarium, of an ovariole of Oecanthus, from an osmic acid dissection. × 600.

Fig. 26. Longitudinal section of the germarium of Oecanthus near its junction with the vitellarium, or follicular portion of the ovariole. × 560.

Fig. 27. Optical section of the smaller part of the vitellarium of Oecanthus, from a hydrochloric-alcohol preparation. × 160.

Figs. 28, 29. Two ova of Oecanthus in which the germinative vesicle has come to the surface preparatory to its disappearance. The vesicle lies in contact with the vitelline membrane. Fig. 28 × 30; fig. 29 × 25

Fig. 30. A cell from the follicular epithelium of an ovariole of Oecanthus niveus, in which the original nucleus has given rise to three others. × 560.

Fig. 31. A serosa nucleus immediately after division. Acetic-acid carmine. × 560.

Figs. 32 and 34. Serosa cells treated with acetic acid carmine. × 560.

Fig. 33. Four serosa cells of Oecanthus treated with acetic acid carmine. × 600.

Fig. 35. Endodermic or yolk nucleus in the uninjured egg; the granules were streaming in the direction indicated by the arrows. × 800.

Figs. 36, 37, 38, 42 and 44. Free cell elements from the yolk of an egg of Oecanthus in which the germinal band was formed. They are the nuclei of yolk cells. Treated fresh with osmic acid, stained in Beale's carmine, mounted in glycerine.

Fig. 39. Three papillae broken off the micropylar cap. The central lumen tapers to a point near the extremity of the papilla. The fine lines radiating from the lumen give it a plumose appearance. × 500.

Fig. 40. Surface view of a papilla showing a groove on its upper surface. × 600.

Fig. 41. Yolk nucleus. HCl. acohol solution, alum carmine, mounted in balsam. × 560.

Fig. 43. Three albuminoid masses treated while fresh with 0.25 % osmic-acetic acid solution, stained in picro-carmine, mounted in benzole-balsam.

Figs. 45, 46. Lateral and dorsal views of the mandible at the time of hatching. × 65.

Fig. 47. Surface view of the eye of Oecanthus soon after hatching. × 125.

Fig. 48. Eight germinative vesicles of Oecanthus and Acheta, one of them from an acetic acid preparation, the others from gold chloride and glycerine preparations, all magnified about 300 diameters.

PLATE XXI.

Figs. 1, 2, 3, 4, 6, 7, 13. Serosa nuclei treated while fresh with osmic acid, stained in Beale's carmine, mounted in glycerine. × 1000.

Figs. 5, 11 and 12. Sections of yolk nuclei from osmic-acetic acid preparations, stained in picro-carmine, mounted in benzole-balsam. × 800.

Fig. 8. A nucleus from the cells of the follicular epithelium of an ovariole of Oecanthus. Chromic acid preparation. × 300.

Fig. 9. Yolk nucleus fresh in chromic acid, Beale's carmine. × 800.

Fig. 10. Five yolk nuclei from a fresh preparation of an Oecanthus egg.

Figs. 14-17, 20. Nuclei of serosa cells treated while living with acetic-acid carmine. Fig. 20 shows the cell wall.

Figs. 18, 19, 21, 22. Free cell elements from the yolk of an egg of Oecanthus in which the germinal band was formed. They are the nuclei of the yolk cells. Fresh in osmic acid, stained in Beale's carmine, mounted in glycerine. × 800.

Fig. 23. Section of an unfecundated egg. HCl. alcohol solution, neutral carmine. × 15.

Fig. 24. Part of a section through an ovarian follicle of Oecanthus, prepared in hydrochloric alcohol stained in picro-carmine, benzole-balsam. × 560.

Fig. 25. Transverse section of the germarium of Oecanthus. × 560.

Figs. 26, 28-30. Sections of an ovariole of Oecanthus passing through the germinative vesicle; from a dissection in sodium chloride, stained in picro-carmine, mounted in balsam and benzole. × 560.

Fig. 27. Section of a young germinative vesicle extracted from its follicle. × 560.

Fig. 31. Transverse section of an egg of Oecanthus after the appearance of the blastoderm and yolk cells. × 65. Hydrochloric alcohol, alum carmine.

Fig. 32. Section through the abdominal region of an embryo after the complete closure of the dorsal wall. The section passes through the ovaries of both sides. × 125.

Fig. 33. Section through the dorsum of an embryo before the closure of the dorsal vessel. The heart is seen as two cavities in the ascending edge of the mesoblastic plates. × 500.

Fig. 34. Cross section after the appearance of the fully formed dorsal vessel. × 100.

Fig. 35. Section through the dorsum before the union of the two mesoblastic plates.

Fig. 36. Section through the dorsal vessel in the thoracic region. × 250.

Fig. 37. Section of the stomodaeum near the mouth. × 125.

Fig. 38. Mesodermic structures from the body cavity of the same individual from which fig. 41 was taken. These structures may possibly be the homologues of the segmental organs of worms. × 125.

Fig. 39. Frontal section of the nervous cord in the maxillary and mandibular region, showing the fusion of three pairs of ganglia to form the suboesophageal ganglion. × 125.

Fig. 40. Section of the ventral nerve cord in the abdominal region. × 250.

Fig. 41. Section through the maxillary region of an embryo with a fully formed dorsal vessel. The nervous system is cut across in four places. × 65.

Fig. 42. Section of the egg of Oecanthus with a young blastosphere of Teleas *in situ*. From an osmic-acetic acid, picro-carmine, balsam preparation. × 100.

Figs. 43-46. Nuclei from the follicular epithelial cells of an ovariole of Oecanthus. Osmic and chromic acid, Beale's carmine. × 1000.

Fig. 47. A yolk nucleus exhibiting interesting conditions of nucleolar structure. × 160.

Figs. 48-50. Same as figs. 43-46.

PLATE XXII.

Fig. 1. Longitudinal section of an embryo shortly after revolution. The serosa cells by a process of degeneration set free their large nuclei; these pass into the mesenteron and the body cavity and there undergo various changes. By an endogenous process each nucleus in the body cavity furnishes from two to three nuclei which, on liberation from the membrane of the mother nucleus, become blood corpuscles. In this stage the sexual organs are seen as a pair of elongated cell masses in connection with the heart × 65.

Fig. 2. One of the nuclei from the fibrous portion of the brain, showing its relations to the fibres. × 560.

Fig. 3. One of the serosa nuclei from the body cavity. × 250.

Figs. 4 and 5. Two stages in the development of the sexual organs. Fig. 4 represents the cell mass before it begins to elongate. Fig. 5 represents the same after taking on the general shape of the future ovary. Within an imperfect lumen are seen several cells, larger than their fellows with peculiar bar-shaped nucleoli. These are the germs of the ova. Fig. 4, × 300; fig. 5, × 250.

Fig. 6. The relations of the fibres of the longitudinal and cross commissures of one of the thoracic segments at this stage. × 500.

Fig. 7 Three pairs of large granular nuclei from the three thoracic ganglia of fig. 1. × 250.

Fig. 8. Cross-section of an abdominal ganglion showing a triangular remnant of the middle cord. The two Seitenstränge have not completely united. × 125.

Fig. 9. A portion of the splanchnic mesoblast and its lining endoderm, from the region of the proctodaeum of fig. 1. × 250.

Fig. 10. Section of a fully formed dorsal vessel. The section is taken from the head region. × 250.

Fig. 11. Section through the maxillary region of an embryo with the dorsal wall fully closed. × 125.

Fig. 12. Section of the heart from the abdominal region. Two nuclei are seen in the walls of the vessel. These are the nuclei of the two cells which compose the vessel in this section. × 250.

Fig. 13. Section of an embryo after revolution, in the region of the third thoracic appendage. The gill organ is cut through at its union with the body wall. The cavities extend the entire breadth of the organ and are irregular both in size and in their course. × 125.

Fig. 14. Section of an embryo passing through its gill organ. × 125.

Fig. 15. Section of the oesophagus near its termination. × 150.

Fig. 16. Section passing through the commissural cords before their connection with the suboesophageal ganglion. × 250.

Fig. 17. A portion of the outer lobe of the right maxilla. × 250.

Figs. 18–22. Successive sections of an embryo before revolution, passing through the proctodaeum and through the flexures of the abdomen. Osmic-acetic acid preparation, stained in picro-carmine, mounted in benzole-balsam. × 50.

Fig. 23, 24. Sections of the same embryo through the first pair of maxillae and the antennae, respectively.

Fig. 25. Longitudinal section of an embryo. × 40.

Fig. 26. Section through the abdominal region of this stage. × 125.

Fig. 27. Transverse section of a germinal band of Oecanthus near the age shown in pl. 18, fig. 5.

Fig. 28. Transverse section of the germinal band very soon after the appearance of the mesodermic cells. × 100.

PLATE XXIII.

Fig. 1. Transverse section through the mandibular segment of an embryo after the closure of the dorsal wall, showing the invaginations for the salivary gland and trachea of left side of this segment. × 125.

Fig. 2. Section of another embryo between the mandibles and first maxilla. The section passes through the anterior part of the dorsal "plug" of the mesenteron, which has passed completely within the body at this stage. On either side of the heart are seen two continuous tubes. × 125.

Fig. 3. Transverse section through the supraoesophageal ganglion. × 125.

Fig. 4. Transverse section of the oesophagus in the maxillary region. × 125.

Fig. 5. Transverse section of the abdomen passing through the proctodaeum at the point of origin of tha three Malpighian tubes. These primitive tubes bifurcate soon after leaving the body of the proctodaeum. × 65.

Fig. 6. An oblique transverse section of the the brain. × 125.

Fig. 7. Amoeboid cells found in the yolk previous to the formation of the blastoderm. Some of these cells go to the surface while others remain in the yolk and form the endoderm and mesoderm. These are taken from fig. 31, pl. 21. × 800.

Fig. 8. Transverse section of a germinal band of about the same stage as fig. 3, pl. 19. The amnion is seen on either side of the band as a few small cells closely pressed upon the ectoderm. × 800.

Figs. 9-12. Sections through the thoracic and abdominal regions of the embryo to show the manner of invagination of a median element to form a part of the nervous system. Osmic acid, balsam preparations. Figs. 9 and 11 × 125; figs. 10 and 12 × 250.

Fig. 13. Transverse section through the head at the stage represented in pl. 18, fig. 17, passing through the oesophagus and upper lip. Osmic acid preparation. × 225.

Fig. 14. Several spindle-shaped ectoderm cells from near V, fig. 13. Under a low power the large oval or spherical nuclei are easily mistaken for cells. × 560.

Fig. 15. A slightly oblique, transverse section through the anterior part of the brain of an individual near the stage figured in pl. 19, fig. 5. Osmic acid, picro-carmine, balsam preparation. × 125.

Fig. 16. Section through the eye at this stage. × 250.

Figs. 17, 18, 19 and 20. Nuclei. Fig. 19. An endodermic nucleus. The others are nuclei from ovarian epithelium of Oecanthus.

Figs. 21, 22. Surface view and optical section of a blastosphere of Teleas in which the germinal band has made its appearance. Shading in fig. 21 diagrammatic. × 100.

Fig. 23. Optical section of a younger blastosphere. No cells are seen except those composing the single-layered wall. × 125.

Fig. 24. Optical section of a blastosphere with the primitive fold partly differentiated. *hf*, the head region of the fold. *M*, a patch of mesoderm cells immediately beneath the ectoderm. × 125.

Fig. 25. An unknown parasite found in the egg of Oecanthus niveus. *h*, the head end lying in contact with the vitelline membrane. The body wall in the abdominal region was pushed out into three finger-like processes. × 100.

Figs. 26–30. Different views of the same blastosphere in the uninjured egg of Oecanthus. Figs. 27 and 28 are optical sections of the blastosphere in a plane grazing the upper surface of the germinal band; fig. 26. frontal (ventral) view of the germinal band; fig. 27, lateral view; fig. 28, an oblique dorsal view. In fig. 29 the posterior termination of the germinal band is shown. Fig. 30, nearly the same as fig. 29, but more oblique to the dorso-ventral axis.

Fig. 31. A young blastosphere in its spherical mass of protoplasm. × 125.

Figs. 32, 33. Blastospheres on the surface of which the primitive fold has appeared. The segmentation cavity is partly filled by the mesodermic cells. × 125. In fig. 33 amoeboid cells are shown.

Fig. 34. Ectodermic cells from different blastospheres. A. treated with osmic-acetic acid solution followed by picro-carmine; B. a single cell much larger than the others. Acetic acid carmine, glycerine preparation; C. surface view of cells *in situ*. Beale's carmine, glycerine preparation; D. from an acetic-acid carmine, glycerine preparation. All × 250.

Fig. 35. A section of the blastosphere figured in pl. 21, fig. 42. × 800. The thinning is probably caused by reagents.

Fig. 36. Blastosphere collapsed by reagents in a manner resembling a gastrular invagination. × 125.

PLATE XXIV.

Fig. 1. An egg of Oecanthus with the three stages of Teleas *in situ*. × 30.

Fig. 2. Side view of a well advanced first, or spindle-shaped, larva. There is a third prominence between the frontal and mouth promontories. Four of the teeth at the base of the caudal appendage are arranged in pairs. There are five incomplete girdles of spines. Osmic acid preparation. × 125.

Figs. 3 and 4. Two views of a cylindrical larva near the stage shown in figs. 8 and 9. × 125.

Fig. 5. Cephalic portion of a spindle-shaped larva. The frontal process is seen to be filled with granular protoplasm; the mandibles and their muscles are well developed. Acetic acid preparation. × 500.

Fig. 6. Ventral view of the same showing the manner in which the oral muscles radiate from the mouth opening. On either side the body are seen the cup-shaped organs. × 500.

Fig. 7. Side view of the cephalic portion of another larva showing the segmental constrictions in the course of the enteric canal of this part. × 125.

Figs. 8 and 9. Side and ventral view of another larva. The mesenteron and stomodaeum have not yet united. Behind the enteric mass of cells is seen the germ of the sexual organs. The ventral band is seen as a thickening of the hypodermis limited to the middle of the larva. × 125.

Fig. 10. End of the abdomen of another larva, bearing the caudal appendage and seven, short, stout spines. The hypodermic nuclei indicate the termination of the cell elements in this region. The caudal appendage is filled with a finely granular protoplasm and at its tip is covered with bristles. × 800.

Fig. 11. View of the enteric and sexual tract of a larva near the same degree of development as those shown in figs. 3 and 8. × 125.

Fig. 12. A larva with three greatly developed spines. They are placed between the girdles of bristles and are nearly equal in size to the caudal spine. × 65.

Figs. 13, 14. Side and ventral views of another larva. The frontal process ends in an enlargement. The mesenteron and stomodaeum are united. The wall of the blind end of the mesenteron could not be distinguished in this specimen. × 125.

Fig. 15. Side view of the cup-shaped organ of the larva represented in fig. 19. × 200.

Fig. 16. Nuclei in the hypodermic syncytium of a larva. × 500.

Fig. 17. An oblique ventral view of the mandibles and lower lip of another larva. × 150.

Fig. 18. Lateral view of the end of the caudal appendage. × 250.

Fig. 19. Ventral view of a larva soon after entering upon the cyclops stage, to show the cuticular structures. × 125.

Fig. 20. Lateral view of the same, to show the muscular system. × 125.

Fig. 21. Second larva in which the nervous band and germs of the sexual cells are not fully differentiated. The stomodaeum and mesenteron are fully formed but the proctodaeum has not yet appeared. The muscular system is partially developed. × 125.

Fig. 22. Dorsal view of the same individual, to show the dorsal muscles. × 125.

Fig. 23. Lateral view of the mesenteron and nervous system of another larva. × 150.

Fig. 24. Ventral view of the cuticular structures of the cephalo-thorax. × 125.

Fig. 25. Lateral view of a larva approaching an ecdysis. × 75.

Figs. 26, 27. Dorsal and posterior aspects of the genital cell mass of an individual in the cyclops stage × 60.

Fig. 28. Striated muscle from the band-like muscles of the abdomen. × 500.

Fig. 29. Transverse section through the abdominal region. The abdominal appendage is seen in section, lying above the body. The nervous cord shows a distinct lumen and lies imbedded in a mass of hypodermic and mesodermic elements. × 150.

Fig. 30. The germs of the sexual organs from another embryo.

PLATE XXV.

Figures 1–21 Teleas. Figures 22–33 Oecanthus.

Fig. 1. Obliquely ventral view of a cyclops larva entering upon an ecdysis. The two swollen cuticular sacs near the fin organs illustrate the manner in which cuticula and hypodermis separate. × 150.

Fig. 2. The mass of nerve and sexual cells lying on the dorsal side of the mesenteron.

Figs. 3 and 4. Side and dorsal views, respectively, of the germs of the sexual organs. In fig. 3 the connection with the mesenteron is shown. × 125.

Fig. 5. Side view of the abdominal region of another larva showing the germs of the sexual organs still united to the nerve cord. They are also connected to the mesenteron by the usual protoplasmic filaments × 75.

Fig. 6. Surface view of the cup-shaped structure from the right side of the same. × 250.

Fig. 7. Ventral aspect of the larva shown in fig. 1. × 150.

Fig. 8. The cells of the mesenteron seen from above. × 500.

Fig. 9. Lateral view of the larva with the nervous system well developed. × 125.

Figs. 10, 11. Sections of the larva, from osmic acid, picro-carmine, balsam preparations. Fig. 10. Transverse section through the mandibular region of the head. The mesenteron is intimately connected with the nerve cord. × 150. Fig. 11. Longitudinal section passing obliquely through the body. The germs of the sexual organs, the abdominal nerve mass and the surface of the mesenteron are seen in this section. × 75.

Figs. 12 – 17. Sections of the cyclops larva, from osmic acid, picro-carmine and balsam preparations.

Fig. 12. A portion of the cuticula of the abdomen showing the manner of origin of the mandibular muscles. × 250.

Fig. 13. Longitudinal section nearly parallel to the dorso-ventral axis of the body. The nervous cord is seen ending in a thickened portion which is folded in an S-shaped manner. Lying dorsad of this and behind the mesenteron are seen the germs of the sexual organs. × 75.

Fig. 14. Transverse section through the abdominal region of a larva younger than that represented in fig. 5. × 75.

Fig. 15. Hypodermal layer of protoplasm containing nuclei. × 500.

Fig. 16. Section of the germ of the sexual cells. × 250.

Fig. 17. Transverse section through the [illegible] glands are seen nearly cut off from the [illegible] cord is but slightly differentiated. × 250.

Fig. 18. Lateral view of the [illegible] of the [illegible] × 100.

Fig. 19. Lateral view of the nervous system [illegible] left half of the oesophageal commissure. × 150.

Fig. 20. Fin organ of the same individual. × 500.

Fig. 21. Dorsal view of the left half of the [illegible]

Fig. 22. [illegible] style of [illegible] male Oecanthus, showing [illegible] its basal portion. × 125.

Fig. 23. [illegible] of the [illegible] organs showing their parts. × 125.

Fig. 24. A portion of the vagina, [illegible] the large mucous glands. × 65.

Fig. 25. A portion of the vaginal wall showing its [illegible] the cells of the lining epithelium. × 125.

Fig. 26. [illegible] which is split open [illegible] stem. Above are seen the rows of [illegible] coverings, which [illegible]

Fig. 27. Section of the same [illegible] wood and bark [illegible] keep out rain, etc. *b*, egg pit uncovered, [illegible] the position of the egg in the pit. × 5.

Fig. 28. Side view of the cap.

Fig. 29. Theoretical section of the first [illegible] × 20.

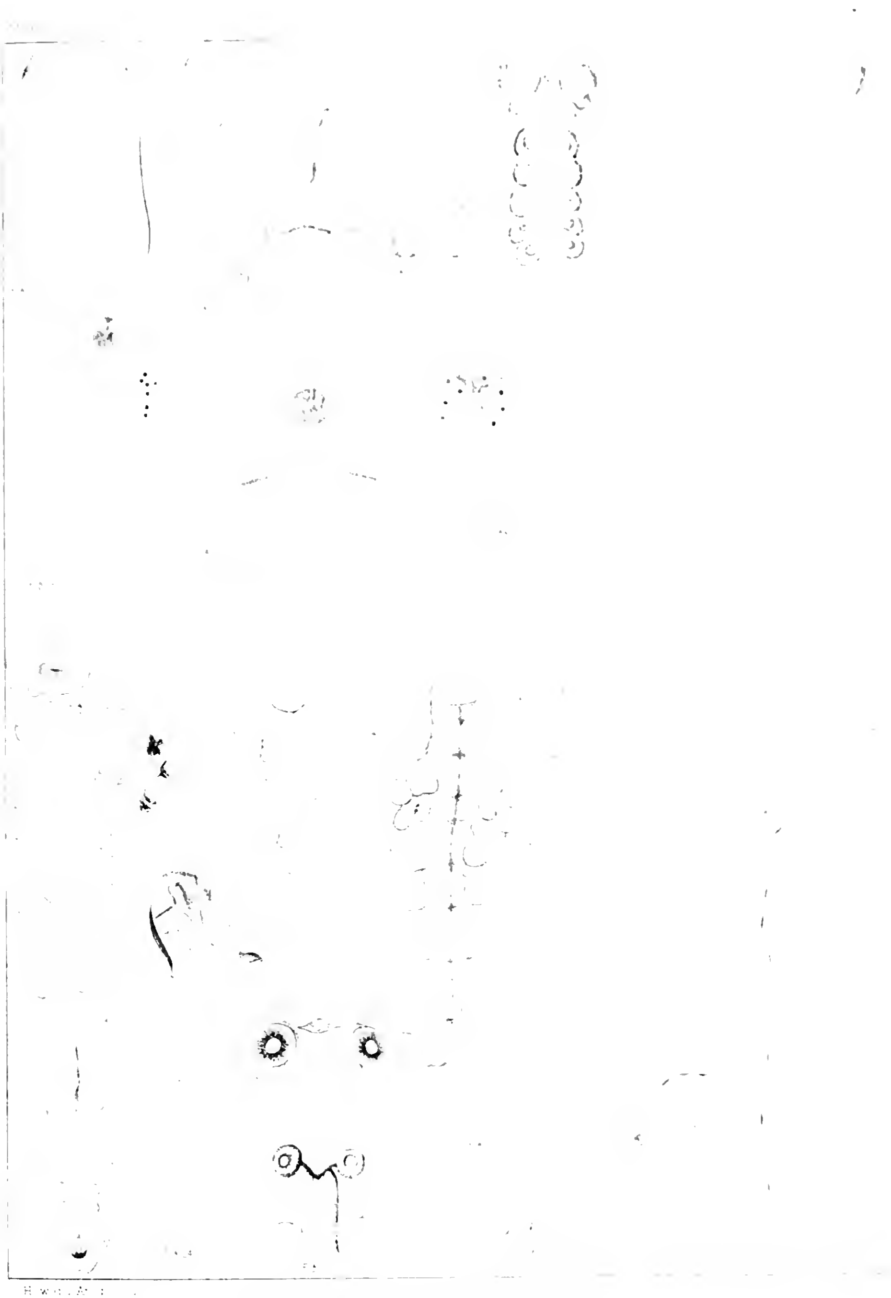
Fig. 30. Transverse section passing through the external opening of the [illegible] The genital armature is developed from the edges of the fold, *g. a.*

Fig. 31. Lateral view of part of the head and thorax of an embryo just before the [illegible] the dorsal wall. The plug of serosa cells (remnant of yolk sac) projects.

Fig. 32. Camera outline of an embryo within the uninjured egg. The tail body is unusually large. × 25.

Fig. 33. Surface of the micropylar cap from which the outer cap has been removed. × 25.

Fig. 34. Tip of the right half of the ovipositor of Oecanthus. × 50.



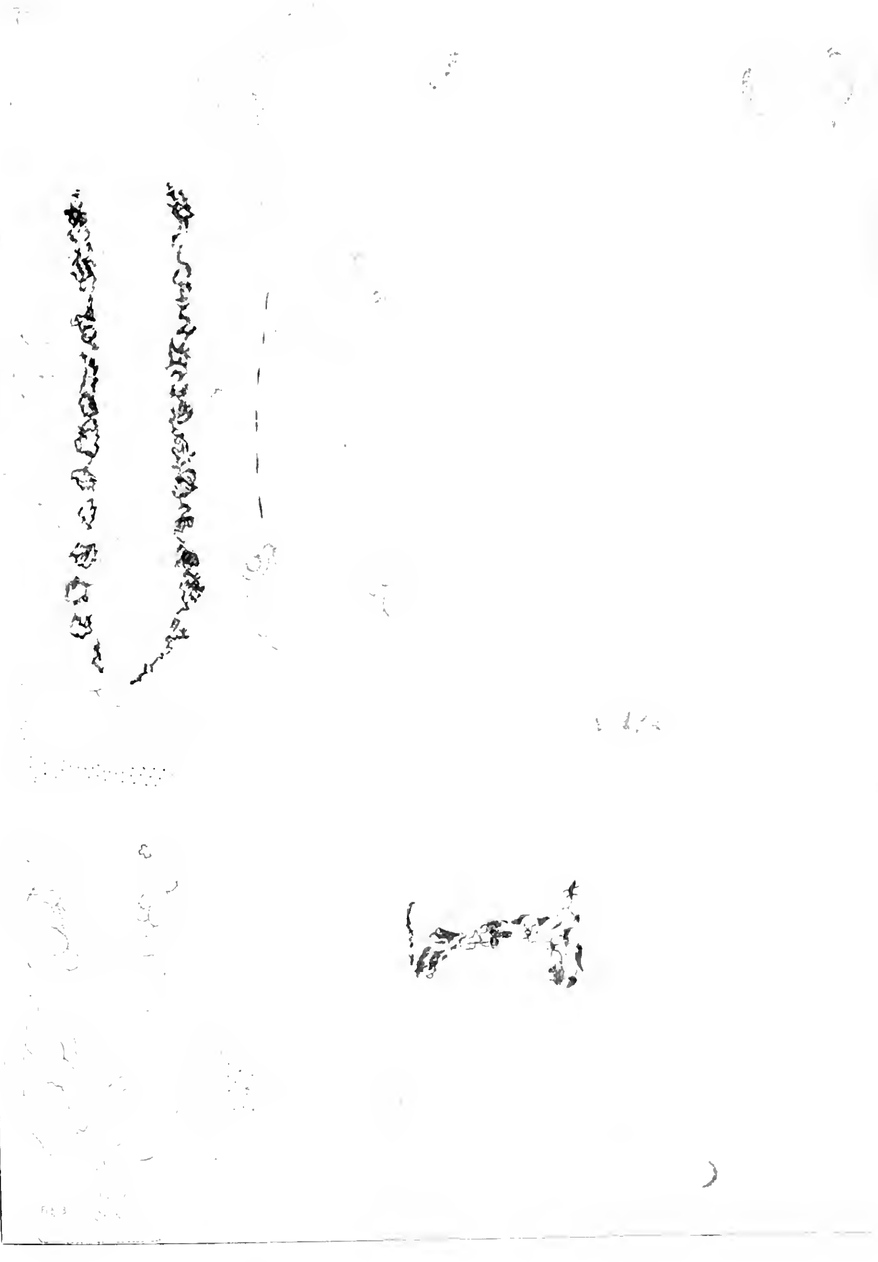
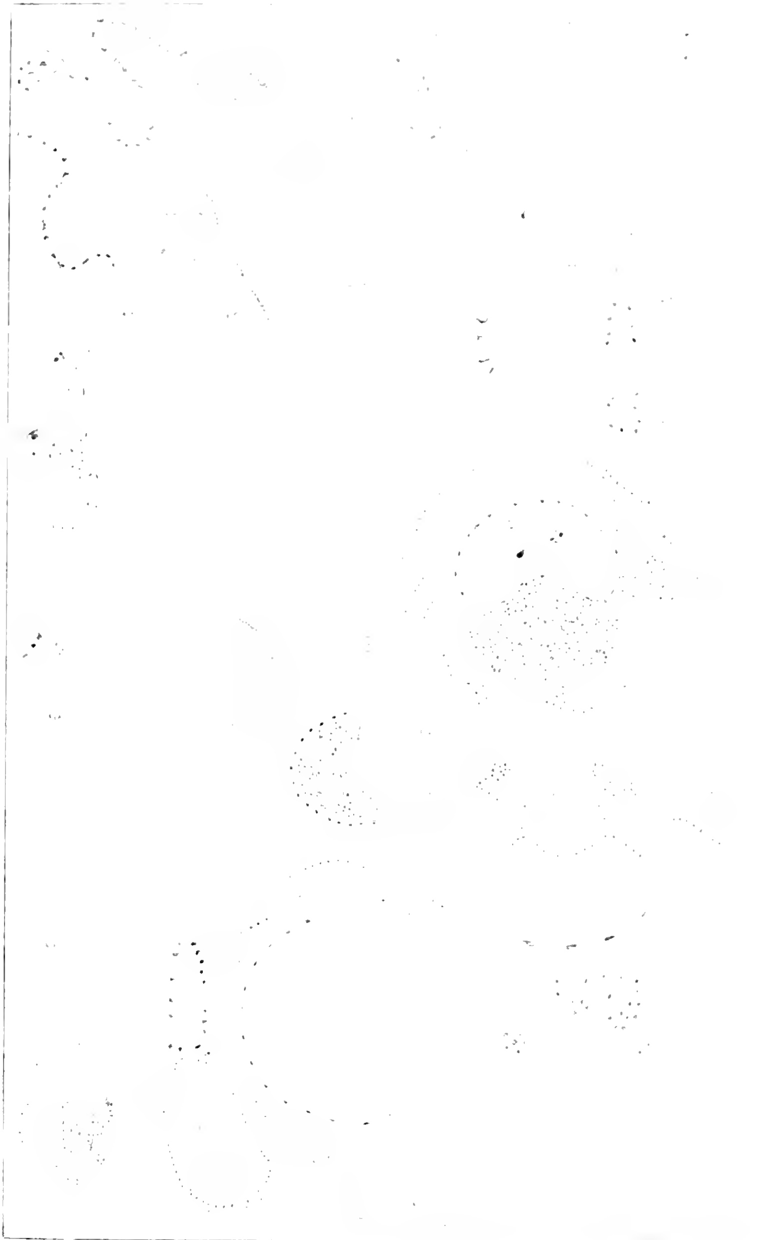
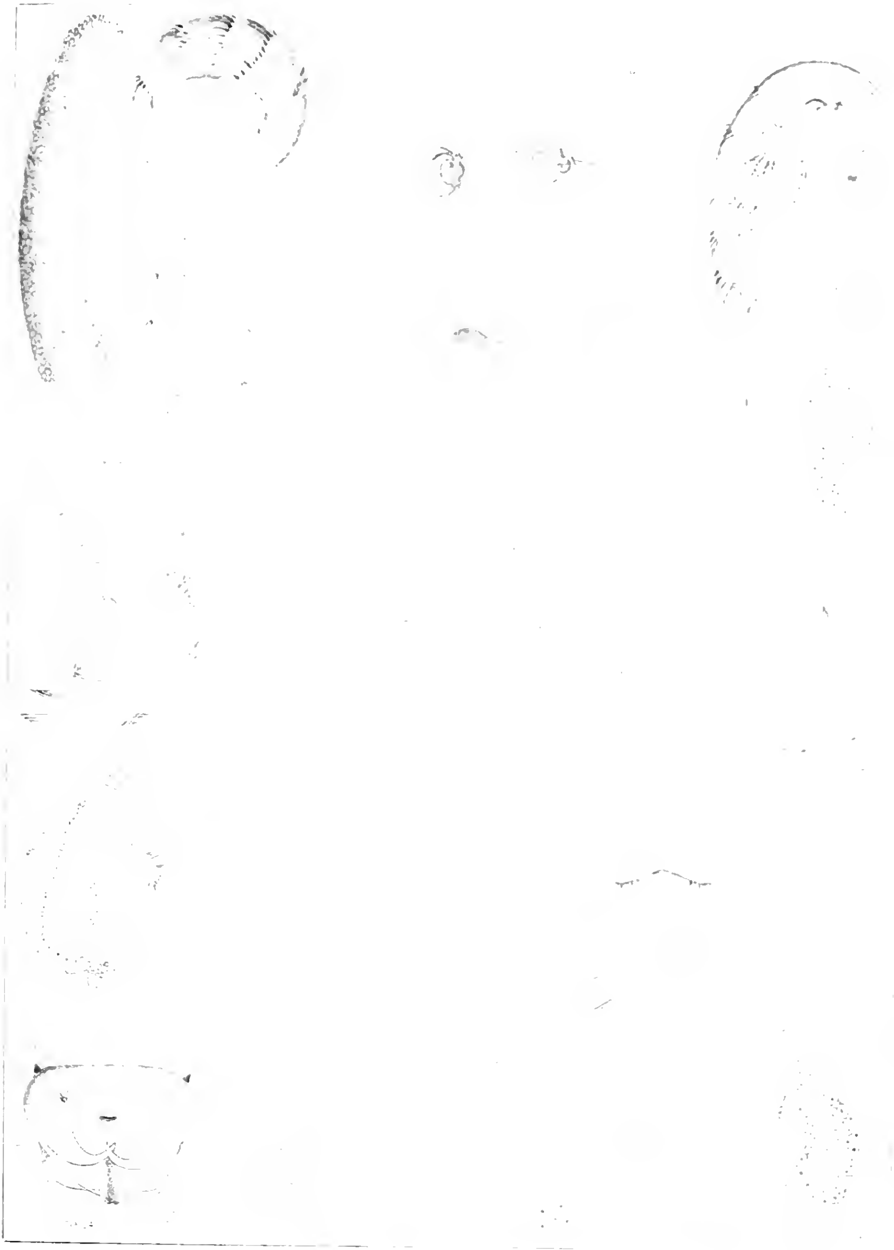


Fig. 3





IX. Two New and Diverse Types of Carboniferous Myriapods.

By Samuel H. Scudder.

Read April 5, 1882.

Characteristics of a distinct type of carboniferous myriapods were recently given in a paper on the Archipolypoda, or gigantic spined myriapods of the coal measures. In collecting the material for that memoir some other striking forms fell under notice, which at first were set aside as having no close connection with my studies; but which, with more ample material and careful inspection, proved to be allied, though remarkably distinct. It is the purpose of the present paper to bring these strange forms to the notice of naturalists. They belong to two distinct types, each differing considerably from other known ancient myriapods. One of these types is here noticed for the first time; the other and more remarkable type is that figured in the Illinois Geological Reports, to which Messrs. Meek and Worthen applied the name of Palaeocampa, and of whose affinities there has been much doubt and some public discussion.[1]

For the opportunity of studying these interesting animals, the writer is entirely indebted to his friends at Morris, Ill., Messrs. J. C. Carr, P. A. Armstrong, and F. T. Bliss, who have generously placed at his disposal the material they have, with great pains and assiduity during a number of years, gathered in the nodules in the shales of Mazon Creek in that vicinity.

The first of these new forms, to which the name of Trichiulus may be given, probably belongs to the Archipolypoda. Five specimens of different species have been examined, but they do not together furnish all the details that could be desired, even in those points where most of the Euphoberiae and allied genera are sufficiently clear. They may be described (pl. 27) as jointed vermiform myriapods, tapering considerably from in front backward. The segments of the body are unusually short and probably consisted of two ventral plates to every dorsal plate, furnished profusely with rows of papillae, apparently arranged in definite series both longitudinally and transversely, and bearing long flexible hairs which were sometimes much longer than the width of the body and formed a thick and uniform flowing mass entirely concealing the body. The body, and especially the hinder half, was capable of being tightly coiled, as in modern Iulidae; more than this can hardly be said. The relation of dorsal and ventral plates is by no means certain and is presumed mainly from certain features which also occur in some obscure but indubitable specimens of Archipolypoda, and which are there referred with little doubt to a separation of the dorsal and

[1] For reference to this, see the bibliographical citations under the description, *infra*, of Palaeocampa anthrax.

ventral fields. It is also supported by a vague appearance of what seem to be legs on one or two of the specimens, and which show two pairs to each dorsal segment. The close general resemblance of most of the species to the species of Euphoberia is also an argument in favor of the same supposition; and would, perhaps, by itself, be considered sufficient to one studying these forms, were it not for the unexpected discovery of a very distinct type of chilopodiform myriapods next to be considered.

This second type, as we have remarked, has been known to naturalists for some time under the name of Palaeocampa, given to it by Messrs. Meek and Worthen in 1865, under the supposition that it was a caterpillar. The original specimen, figured in 1866, was destroyed by fire a year or two later, but a better specimen enabled these naturalists to give further description of the spines in the same year that I questioned the lepidopterous nature of the fossil; and to express the opinion, that, as I had suggested from the figure alone, "it was more probably a worm." I have now received, through the favor of Messrs. Carr and Bliss, three remarkably well preserved specimens of what is undoubtedly the same creature, and which show that the animal combined some most extraordinary features. One of these specimens, the discovery of Mr. Bliss, shows the legs distinctly on both halves of the split nodule in which it occurs, and gives one much fuller information concerning this ancient creature than one could gain from the legless specimens otherwise known.

But for my previous study of the Archipolypoda of Mazon Creek, and the revelation which these ancient types give of the divergence of structure between extinct and modern forms of Myriapoda, it would have been difficult to reach the full conviction that Palaeocampa was a myriapod. It is a caterpillar-like, segmented creature, three or four centimeters long (pl. 26), composed of ten similar and equal segments besides a small head; each of the segments excepting the head bears a single pair of stout, clumsy, subfusiform, bluntly pointed legs, as long as the width of the body, and apparently composed of several equal joints. Each segment also bears four cylindrical but spreading bunches of very densely packed, stiff, slender, bluntly tipped, rod-like spines a little longer than the legs. The bunches are seated on mammillae and arranged in dorsopleural and lateral rows.

The individual rods have an intricate structure (pl. 26, figs. 1–4); instead of being striate, as supposed by Meek and Worthen in their last examination, they are furnished externally with about eighteen longitudinal, equidistant ridges, about half as high as their distance apart; the edges of these ridges are broken into slight serrations at regular intervals about equal to the distance between neighboring ridges, the highest point of each serration being toward the apex of the spine; the body of the ridge itself appears as if broken at each serration. The intervening space between neighboring ridges is equally divided by two or three exactly similar, but miniature ridges, serrated at more frequent intervals. This serration of both larger and smaller ridges, with the apparent jointing or incision of the ridges to the base at the lowest point of each serration, gives the whole spine a jointed appearance; but a close inspection of the floor of the spine itself between the ridges shows no sign whatever of any break in its perfectly smooth surface. The diameter of the spines is only about one-tenth of a millimeter, and yet it gives room for an exquisitely regular division of its periphery by seventy or more delicate ridges, every fourth one higher than the intervening, and all broken at minute intervals by uniform serrations (pl. 26, fig. 2). The preservation of these structures from carboniferous times is only less remarkable than the occurrence, apparently so near the origin of the type to which it belongs, of ornamentation of such excessive delicacy, finish, complication and regularity. I cannot discover that dermal appendages of such delicate and specialized organization occur anywhere to-day among arthropods, unless it be when developed as scales, as in Lepidoptera, and occasionally in other groups of hexapods; some chaetopod worms have indeed hairs of curious asymmetrical structure, often very delicate and somewhat specialized, but never, so far as I can learn, to nearly so high a degree as here. The collection of these rods into fascicles is also not a little curious, and is again a feature known now in arthropods only in a few instances, such as some tufts of hairs in lepidopterous caterpillars like Orgyia; or the pencils of hair-like scales in the males of some perfect Lepidoptera, e. g. at the tip of the abdomen in Heliconia, Danais, Agrotis, Leucarctia, etc.; or in the terminal fascicles of barbed bristles in the myriapodan genus Polyxenus.[1]

There is no group of animals into which such a jointed creature as this could fall excepting worms, myriapods, or the larvae of hexapod insects. The certainty that this animal possessed a single pair of well developed legs of identical character on every segment of the body behind the first segment or head is of itself sufficient evidence to exclude it both from the worms and from the larvae of hexapod insects. No such legs or leg-like structures occur to-day in worms, and it would be idle to look for them in their ancestors of carboniferous times. The only approach to such an appearance in hexapod larvae is in the young of tenthredinous Hymenoptera, where, however, a difference of great morphological significance is found between the true or thoracic legs and the pro-legs or those attached to the abdomen; a difference based on one of the most essential underlying features of their structure as hexapods. No such difference occurs in Palaeocampa, and it is, therefore, impossible to conceive of it as the larva of a hexapod insect of any sort.[2]

In myriapods only do we find a repetition of legs of exactly similar structure on every or nearly every segment of the body:[3] by this test Palaeocampa is a myriapod; and now that we have found ancient types of this group, like the Archipolypoda, bearing huge and bristling spines arranged in series along the sides of the body, we need not be at all disconcerted at discovering this new type, with longitudinal series of fascicles of stiff rods, although we cannot restrain our surprise and admiration at their exquisite intricate structure.

Accepting Palaeocampa then as a myriapod, we may next ask what relation it bore to the myriapods of the same period and found in the same waters, and also to myriapods of to-day.

The differences between the stout, forked and bristling spines of the Archipolypoda and the close-set but spreading bunches of highly organized stiff rods of Palaeocampa appear upon the barest statement. Were it not, however, for the complicated ornamentation of

[1] See *Proc. Bost. Soc. Nat. Hist.*, XXII, 66, figs.

[2] Dr. Packard has recently remarked (*Proc. Amer. Phil. Soc.* XXI, 208): "It seems to us that the larvae of the neuropterous Panorpidae, with their two-jointed abdominal propelegs, small head and singularly large spinose spines, arising in groups from a tubercle or mammilla, come nearer to Palaeocampa than any myriapod with which science is acquainted." This opinion, expressed since this paper was written and since the publication of my general results in the *American Journal of Science*, the author supports by no facts beyond what are implied in the above quotation. How he will account for the unquestionably close relationship of Palaeocampa, Trichiulus, and Euphoberia does not yet appear.

[3] Some smaller groups, formerly, and by some authors still, considered as belonging to the myriapods, must be excepted from this statement; their relation to Palaeocampa will be discussed farther on.

the rods themselves, the distinction between the fascicles of Palaeocampa and the spines of Euphoberia would be hardly greater than that between the latter and the long hairs of Trichiulus; so that to this feature alone we cannot grant so high an importance as to another which has already been named: the presence in Palaeocampa of a single pair of legs (and consequently, to judge by analogy, of a single ventral plate) to each segment; while there are two ventral plates and pairs of legs to each segment in Archipolypoda. This is a difference of profound significance, which has separated the prevailing types of myriapods down to the present day, lying as it does at the base of the distinctions between the living chilopods and diplopods. The discovery of this type is of the greater importance because we have hitherto known nothing of any chilopodiform myriapods previous to tertiary times, unless Münster's dubious *Geophilus proavus* from the Jura possibly be an exception.[1]

In studying the Archipolypoda we necessarily confined our comparisons with modern types to the Diplopoda, because of their common possession of the fundamental feature just named: in the same way the comparisons between Palaeocampa and recent forms must be reduced to the common features or the radical distinctions which appear in studying the Chilopoda. Now although the structure of Palaeocampa can be far less perfectly known than that of the equally ancient Euphoberia and its allies, enough can be seen to point conclusively to wide and important differences between it and modern Chilopoda.

In Chilopoda, of which the modern scolopendra or centipede is the type, the body is always depressed, formed of many segments, rarely as few as sixteen behind the head, each of which is compound, being formed of two sub-segments, one of them atrophied and carrying no appendages; both dorsal and ventral plates are coriaceous, of nearly equal width, and possess no armature whatever excepting the simplest hairs, which are occasionally scattered over the surface. The larger sub-segment bears a single pair of legs, which are composed of five slender, cylindrical, sub-equal joints beyond the coxa, and armed with a single apical claw; they are attached to the intersutal membrane uniting the distinct dorsal and ventral plates of each segment and are therefore separated by the entire width of the broad ventral plates. The hindmost legs are transformed to anal stylets, while the first two pair are more profoundly transformed to subsidiary mouth parts, the first becoming palpi and the second stout nippers. The head really composed of eight primitive segments, is apparently made up of two, each of which is generally of about the same size as the body segments and as distinctly separated; the stout biting jaws, composed of the second pair of legs, spring from this second segment of the head, and the palpi or first pair of legs from the hinder part of the first cephalic segment; the anterior part of the same bears the many-jointed simple antennae.

Passing now to the comparative study of Palaeocampa, we find that its body was in all probability cylindrical, composed of a limited number of segments behind the head, and the head itself, considerably smaller than the body segments, is composed of only a single apparent segment. The legs of the segment immediately succeeding it are in every respect like those of the rest of the body, and have nothing whatever to do as auxiliary to the mouth. In this point alone we have a distinction as wide and incisive as any which separate the modern Diplopoda and Chilopoda. In the body segments we discover no trace of anything more than a simple ring without sub-division, but as the specimens indicate a coriaceous

[1] Hagen considers this a nereid worm, a suggestion I once adopted, but now find reason to question.

structure like that of modern Chilopoda, and no trace of the division between the dorsal and ventral plates can be seen in any of them, the separation of the segments into two sub-segments, as in Chilopoda, one of them greatly atrophied, could hardly be apparent did it exist. But on the other hand, as we regard the second sub-segment of Chilopoda as atrophied, we should expect to find it fully or partially developed in these creatures, which of all known ancient types are certainly the most closely related to them. Yet we find here no sign of anything more than the simplest possible, uniform, leg-bearing segments, and of a very limited number. In one feature, however, they are not so simple as in Chilopoda; for, as stated, each is provided on each side with two pairs of mammillae, supporting very large bunches of spreading rods, and the rods themselves are sculptured in a very remarkable way. This distinction between the two types, though more striking and noticeable than any other, is in itself by no means so important as the others, but may be added to the catalogue; and it must have some weight, from the total absence of appendages of any sort (beyond scattered hairs) from the dorsal plates of Chilopoda. The position of these rows of fascicles and of the legs indicates that the ventral plates were only a little narrower than the dorsal, and probably of about the same extent as in the Archipolypoda; in this respect they would not differ to any important degree from modern Chilopoda. The legs were different in form, but their poor preservation in the only specimen in which they have been seen prevents anything more than the mere statement of the following difference: while the legs of Chilopoda are invariably horny, slender, adapted to wide extension and rapid movement; those of Palaeocampa are fleshy, or at best subcoriaceous, very stout and conical, certainly incapable of rapid movement, and serving rather as props.

These differences, which underlie every part of the body that is preserved in Palaeocampa, show that while the general accordance of grand features compels us to look upon Palaeocampa as a precursor of the Chilopoda, we must separate it from them in the same way as we separate the Archipolypoda from the Diplopoda. For such a group the name of Protosyngnatha is proposed, indicating its ancestral relations to the Chilopods, or Syngnatha, as they were called by Latreille.

There are, however, two aberrant groups of living animals more or less closely related to myriapods, and placed with them by some authors, with which also we should compare Palaeocampa. The first of these is Peripatus, our knowledge of which has been so much increased of late years, and especially by the researches of Moseley.

In external appearance Peripatus resembles an annelid, but is furnished with a pair of long, jointed antennae, and with numerous fleshy, tapering legs, each armed at tip by a pair of claws; the legs, set wide apart, are obscurely jointed, the joints being perceptible only at the extreme tip and on the apical half of the inner side, above which are the large elongated openings into the nephridia. The entire body is of a leathery texture with no external sign of segments, or of the separation of the head from the rest of the body, except the appendages: namely, the legs, the nephridia opening on the legs, and the ordinary appendages of the head. The same is true when the internal structure of the body is examined, for neither in the disposition of the muscles nor of the tracheal apparatus does it appear that one could judge whether a pair of legs represented one or more segments of the body; even in the nervous system it is only indicated by a small ganglionic swelling next each pair of legs. The tracheae are like extended cutaneous glands, independent of one another, and scattered over the body, and the longitudinal muscles show no regular segmental breaks. This weakness of segmental divisions is nowhere paralleled among hexapods, arachnids or myriapods, and is an indication of very low organization among arthropods generally. The number of legs indicates from 15 to 35 segments in the body, according to the species. The first pair, as they are developed in the adult, are functionless as legs, and are situated (in the specimens I have examined—a South American species, probably *P. Edwardsii*), midway between the antennae and second pair of legs, and not only outside of, but at some distance from the mouth parts, so that the latter are not furnished with auxiliary appendages borrowed from a segment behind the first, as in chilopods: this is further proven by the development of these parts in the two groups. The body is profusely covered above with corrugated papillae, without regular distribution.

From this it will appear that Palaeocampa differs in many essential features from Peripatus, and in most at least of these shows a higher organization. The segments are well separated from one another, and the head is distinctly marked. The number of segments is much less, and each bears clusters of appendages of a highly specialized character. Although no spiracles are present in the remains we have of Palaeocampa, it is clear that respiration must have been effected through linearly disposed openings; since the muscular or mechanical requirements for the movement of a completely segmented body (especially if, as in Palaeocampa, the segments bear a heavy armature), forbid the miscellaneous distribution of tracheae, and demand a well-developed system with the same linear arrangement which we find in the armature. The best that can be said of the respiratory apparatus in Peripatus is that the tracheal bundles show a tendency toward "a concentration along two sides of the body, ventral and lateral." The possession, however, in each type, of a single pair of legs to every segment behind the head indicates an affinity which cannot be overlooked, and which is the more interesting since one of the types is very ancient and the other is universally looked upon as an existing survivor of an ancient type. The form of the body and of the fleshy legs is also similar, but these are minor points; and however close the agreement between these forms, we cannot look upon Palaeocampa, with its undoubtedly well-developed tracheal development, as in any sense the genetic predecesson of Peripatus, for the generally distributed tracheal apertures of the latter could not have developed from a serial disposition, without a degradation of type which, as Moseley points out, many other features combine with this to disprove. It may also be added that while the legs of Palaeocampa are poorly preserved in the only specimen which gives a side view, the presence of nephridial openings, of such an extent and in such a place as in Peripatus, could hardly fail of detection, and they are entirely absent. The presence of these in Peripatus is one of the marks of their inferior organization, or rather of their alliance to an inferior type, the annelids.

The other aberrant group which we must specially notice is Scolopendrella, placed at first among Chilopoda, but recently shown by Ryder and Packard to differ from them in very important features, in some at least of which it agrees with Palaeocampa. The researches of these naturalists, as well as the earlier observations of Menge, clearly prove that it must be separated from the myriapods altogether, and that it is certainly provided with many points of affinity to the Thysanura. Ryder suggests for it an independent place between the Myriapoda and Thysanura under the name Symphyla. Packard, with better reason, would place it within the Thysanura, under which head he would also include the Collembola and Thysanura proper, or Cinura, as he terms them.

Scolopendrella, as these authors point out, differs from the Chilopoda in that the appendages of the segment behind that furnishing the mouth-parts proper do not serve as auxiliary organs for manducation, but are developed, like those of the succeeding segments, as legs, while the mouth parts resemble those of Thysanura, and differ from those of Chilopoda; indeed the whole head is decidedly thysanuriform; the legs are provided with a pair of claws, and the terminal segment bears a pair of caudal stylets with a special function. Besides these points the possession of a collophore is distinctively thysanuran, and the position of the stigmata, between the legs, is different from the position they uniformly maintain in Chilopoda, while it only adds to the great irregularity of place seen in Thysanura. On the other hand, the identity of form in the thoracic and abdominal segments, the full development, upon the abdominal segments, of jointed legs like those of the thoracic segments, and the occasional alternation of leg-bearing and apodal segments in the abdomen, are striking marks of its real affinity to the chilopods. Abdominal appendages, homologous with legs, but unjointed, do, however, occur in Thysanura to a greater degree than in other hexapods, so that we can hardly refuse to admit these polypodous creatures as lowest members of the sub-class of insects proper, although they are the only non-hexapodal type.

Now the separation of the head and its appendages from those of the next succeeding segment distinguishes Palaeocampa from the chilopods in the same way as it does Scolopendrella; so, too, the segments behind the head in Palaeocampa and Scolopendrella, alone of all arthropods in which the head is thus clearly separated, agree in showing no distinction whatever between what may be looked upon as thoracic and what as abdominal, whether in the form of the segment itself, or in the appendages of the segments. These are certainly fundamental points, but when we have mentioned them we have reached the end of all possible affinities, or points of resemblance, unless we may consider the minute structure of the rods in the fascicles of Palaeocampa paralleled by the well-known delicacy of organization of the scales in some Thysanura, though they do not exist in Scolopendrella. The limited number of abdominal segments might be looked upon as a further point were it not that the number is even less than in Scolopendrella or in the Cinura; and that the Pauropida among diplopod myriapods have in some instances even a still smaller number. On the other hand, the character of the legs, the apparent absence of a double claw at their tip, the peculiar armature of the fascicled rods, which forms so striking a feature in Palaeocampa, the want of any caudal stylets, and the complete uniformity of the segments of the body unprovided with distinct dorsal scutes, distinguish Palaeocampa not only from Scolopendrella but from all Thysanura whatever; the general form of the body, too, is altogether different from anything occurring there, even its cylindricity being foreign to the Thysanura, excepting in their highest types among the Collembola. It seems, therefore, clear that the points of affinity between Palaeocampa and Scolopendrella, with the single exception of the separation of the head and its appendages from the body, are precisely those in which Scolopendrella is chilopodan, and that the assemblage of features which our fossil presents are therefore chilopodan rather than thysanuran.

Regarding Palaeocampa then as a myriapod, though of a type very distinct from any known, whether living or fossil, we are brought face to face with two remarkable and somewhat parallel facts: First, that *in this ancient myriapod,* as old as any with which we are acquainted, carrying us back indeed as far as any traces of wingless tracheate arthropods have been found, and, therefore, presumably not far from the origin of this form of life upon the earth, *we find dermal appendages of an extraordinarily high organization,* more complicated, as we have pointed out, than anything of the sort found in living arthropods, excepting the more varied but not more exquisite scales of several orders of hexapods; a form of appendage which it would seem, on any genetic theory of development, must have required a vast time to produce, but which we now seem to find at the very threshold of the apparition of this type of arthropod life.

Second, that *at this early period,* in marked contrast to what we find in other groups of articulated animals, *the divergencies of structure among myriapods was as great as it is to-day.* This is the more surprising because we possess only imperfect remains of a few types, and yet from what we already know of the Archipolypoda on the one hand, and of the Protosyngnatha on the other, they are found to differ quite as much as the Diplopoda and Chilopoda, and in points fully as important as those which separate so sharply these great modern groups. Whether they are to be looked upon, one as the ancestor of one, the other of the other, of these modern groups, is another question. It would certainly be reasonable to consider the Archipolypoda as the common ancestors of both the Chilopoda and Diplopoda; and possibly on the Protosyngnatha as the descendants on one line of a primitive type which, on another line, has retained its integrity up to the present day in Peripatus (and on possibly a third line has reached Scolopendrella); while on that which produced Palaeocampa it has not, so far as we know, survived the carboniferous epoch.

With the facts of structure of ancient and modern types now before us, we are compelled, on any genetic theory, either to presume a great acceleration of development in earlier times or to look for the first appearance of myriapods at a vastly remoter epoch than we have any reason to do from the slight hints in the rocks themselves — a period so remote as to antedate that of winged insects, which are now known from rocks older than any which have yielded remains of myriapods.[1] In a memoir on Devonian insects,[2] I showed the probability, on developmental grounds, that some of the carboniferous insects, "together with most of those of the Devonian, descended from a common stock in the lower Devonian or Silurian period; and that the union of these with the Palaeodictyoptera (of the carboniferous), was even further removed from us in time." The structural relations of myriapods and hexapods render it probable that the former preceded the latter; and in complete accordance with this expectation, the structural relations of the oldest fossil myriapods indicate their apparition at a period earlier than that to which the winged insects are hypothetically assigned. This would compel us to consider the earlier type as aquatic, for which we have presumptive evidence in the structure of the Euphoberidae, and renders it all the more surprising that the penetrating researches of the last thirty-seven years, since the first carboniferous myriapod was discovered, have not yielded the slightest trace of fossil myriapods below the Coal measures.[1] This discrepancy between fact and hypothesis should never be lost sight of, and should stimulate to more searching

[1] This was written before the publication of Mr. Peach's discovery of myriapods in the Old Red Sandstone of Scotland.

[2] Anniv. Memoirs Bost. Soc. Nat. Hist., 1880.

investigations particularly of those articulates of the older rocks whose affinites have not been satisfactorily settled.

It only remains to give descriptions and refer to illustrations of the species of the two groups whose general affinities have been discussed.

Suborder ARCHIPOLYPODA

Family Euphoberidae.

Trichiulus nov. gen. (θρίξ ἴουλος.)

Segments from three to four or five times broader than long, covered closely with tolerably large papillae, which are arranged in definite series both longitudinally and transversely, and support long flexible hairs, which together form a sweeping mass covering the whole body.

These points will serve abundantly to distinguish this genus from the other Archypolypoda described in my previous paper on the subject. They are derived from the study of all the species described below, no one of which, however, presents them all; only one of them shows the sweeping mane of hair enveloping the whole creature; the others either have no hair preserved at all, or at most vague appearances of a mat of hair next the integument; on the other hand the specimen showing the hair so well shows nothing of the papillae which (doubtless) bear them, and which show to perfection in most of the other specimens.

The number of segments appears to vary considerably, from about 20 or more in one species to 35 or more in another; the form appears to be nearly the same in all, the body being much larger at the front than at the hinder extremity, and tapering pretty steadily toward the tail; in one, however, which is fragmentary, no sign of this change is shown. The head end also tapers, but only just next the head itself so far as known, in this respect differing from other Archipolypoda. The head itself, too, joins in this rapid diminution entirely, instead, as in most other Archipolypoda, of being considerably larger than the segments just behind it; its outline, however, is perfectly preserved in only a single specimen, so that this statement should not be taken as absolute. The various species differ from each other in the form in which the body varies in proportion, in the number and relative proportions of the segments and in the frequency and arrangement of the papillae or tubercles from which the hairs originate.

Trichiulus villosus nov. sp.

Pl. 27, fig. 2.

Body composed of more than thirty segments which vary from two to three times as broad as long, being broadest in the stoutest part of the body; it is broadest from the third to about the tenth segment and then tapers very regularly to less than half the diameter at the hinder extremity; the anterior extremity of the body in front of the third segment tapers very rapidly and considerably, the head being only a little larger than the tail — a point seen best in the reverse of the specimen drawn and not appearing on the plate. The whole surface of the body upon both sides, as it lies coiled in an open spiral, is covered with a thick mat of rather fine hairs which appear to be two or three times longer than the diameter of the body. Two or three pairs of short and slender tapering legs can be seen (not given on the plate) depending from the anterior segments; they are scarcely half as long as the diameter of the segments. The length of the fossil if unrolled would be 29 mm.; its greatest diameter is 2.1 mm. The specimen is from the nodules of Mazon Creek and was obtained by Mr. P. A. Armstrong.

Trichiulus nodulosus, nov. sp.

Pl. 27, figs. 1, 3.

Two specimens at hand are referred to this species, though each is so fragmentary that the determination is uncertain.

One of them (pl. 27, fig. 1) represents a dozen segments of the entire width of the creature, being apparently only a fragment of the larger end; it does not taper, and the segments are about four times as broad as long, each furnished with two transverse series of equidistant, small, rounded warts, apparently the bases for appendages of some sort; the series are also equidistant so that the warts are sprinkled over the surface in a very regular fashion, like a checkerboard, in both longitudinal and transverse rows. Each series on the same segment is separated from the other by a transverse depression a little shallower than the sulcation between the segments. The warts are about 1.25 mm. distant from each other and slightly less than half a millimeter in diameter. The length of the fragment is 29 mm., and its breadth 9.25 mm. No appendages of any sort are to be seen; but next the margin in some places are faint signs of delicate hairs, and the discoloration of the skin in the neighborhood may indicate its previous extent.

The other specimen (pl. 27, fig. 3) is longer, but by the method of preservation and the cleavage of the nodule it only shows a portion of the breadth, and neither edge, so that no appendages can be seen, nor any hairs. The same arrangement of warts or tubercles can be seen, rendering it probable that it belongs to the same species as the other. These wartlets are at the same distance apart as in the other specimens, and the series are similarly arranged, the sulcations between the segments being slightly deeper than those between the transverse series of a single segment; but the wartlets appear a little sharper or more conical. The length of the fragment is 45 mm. and its extreme breadth 4.5 mm.; the segments can only be faintly seen over a portion of the fragment, but there were probably about twenty in this piece, which does not seem to reach either extremity. Both specimens are from Mazon Creek and were obtained by Mr. P. A. Armstrong, and are in his collection.

Trichiulus ammonitiformis, nov. sp.

Pl. 27, fig. 4.

Although the single specimen found presents few tangible characters, it differs so much from the others that it seems worth while to make it public. It is of much greater size and is coiled into a slightly open spiral, and being preserved on a side view has a cursory resemblance on the stone to a fossil ammonite. If unrolled it would measure about 115 mm. in length, and its extreme breadth is 11 mm. The head end is broken badly but enough is preserved to show that it tapered anteriorly, the largest part of the body being probably the end of the anterior third; beyond this the body tapered gently to very near the tail, but then diminished very rapidly in size, the tip, however, being rounded; a little before the rapid diminution in size the diameter is 9 mm. There seem to have been about thirty-five segments to the body, about four times as broad as long on the average, not very much arched and least so along the upper portion, where, at least in the fossil, the surface is almost completely flat and shows scarcely a sign of the division of the segments. In certain parts of the fossil there are indications of minute tubercles as if for the support of hairs, but they are obscure and would not have been noticed but for their occurrence in the preceding species. There is, however, along the outer edge an exceedingly faint indication of a delicate mat of very fine hairs, where the surface of the stone, as in T. villosus, is decidedly darker than elsewhere. This specimen also was found by Mr. P. A. Armstrong in the nodules of Mazon Creek.

Suborder PROTOSYNGNATHA.

Palaeozoic myriapods, with a cylindrical body, the head appendages borne upon a single segment; each segment behind the head composed of a dorsal and ventral plate of equal length and, probably, of subequal breadth; the dorsal at least somewhat broader than the ventral, occupying the greater part of the sides of the body, and supporting several longitudinal rows of clustered needles; the ventral plates occupying the entire ventral portion, each bearing a pair of widely separated, stout, fleshy legs, i. e., one pair to each segment of the body behind the head; spiracles probably present in a definite longitudinal row.

Genus Palaeocampa (παλαιός: κάμπη.)

Palaeocampa, Meek and Worthen, Proc. Acad. Nat. Sc. Philad., 1865, p. 52 (1865); — Ib., Geol. Surv. Ill., 2: 410 (1866).

Desmacanthus, Meek and Worthen, Geol. Surv. Ill., 3: p. 565 (1868).

Head corneous with no armature. Body coriaceous, coarsely shagreened, composed of ten segments furnished on each side with two rows, dorsolateral and lateral, of fascicles of needle-like spines, one to a segment in each row, placed upon tubercles near the front of the segments; the fascicles are cylindrical at base, the needles diverging only a little; each needle tapers very slightly, is blunt at tip, and very regularly divided by longitudinal serrated ridges. Legs stout, subequal, about as long as the width of the body, tapering and pointed.

Palaeocampa anthrax, Meek and Worthen.

Pl. 26.

Palaeocampa anthrax, Meek and Worthen, Proc. Acad. Nat. Sc. Philad., 1865, pp. 52-53, (1865); Palaeont. Ill., Vol. 2, pp. 410-411, pl. 32, fig. 3 (1866); — Ib., Vol. 3, p. 565 (1868); Scudder, Geol. Mag., Vol. 5, p. 218 (1868). Figured also in Packard's Guide to Study of insects, fig. 68 on p. 78.

Four specimens of this species have been examined, two of them belonging formerly to Mr. J. C. Carr, of Morris, Ill., and received for study from him, but now in the collection of Mr. R. D. Lacoe, of Pittston, Penn.; a third received from Mr. Lacoe and numbered 1851 in his collection; the fourth obtained by Mr. F. T. Bliss, of Morris, Ill., and in my own collection; all of these are admirably preserved and show both relief and counterpart. Both of Mr. Carr's specimens are preserved from above and have the fascicles spread regularly upon either side of the body. In one (pl. 26, fig. 7), which has the head end as well as the opposite completely fringed with spines, the general cursory resemblance of the whole to the caterpillar of an Arctian is very striking. The rods of the fascicles of the first and second body segments and especially of the first are considerably shorter than those of the succeeding segments, those of the first projecting forward over and concealing the head; in the same way those of the last segment make a complete fringe around the posterior extremity of the body. The fascicles are more readily seen on this than on the other specimens to emanate from tubercles, which are conical and apparently (here at least) higher than their basal breadth. The fascicles are longer than the width of the body, and their most divergent rods are about at right angles to each other. The length of the body in this specimen is 33 mm.; or, with the rods, 40.5 mm.; the width of the body is 5.5 mm.; or, with the rods, 17 mm. The longest rods are 6.5 mm. long.

The second specimen of Mr. Carr's collection (pl. 26, fig. 6) is about the same size as the last, the body measuring 34 mm. by 5 mm.; or with the rods 40.5 mm. by 15 mm. The rods in the fascicles are, however, considerably less divergent and trend a little backward giving them a more bunchy appearance; those of opposite sides of the same fascicle rarely diverge more than 55°; the rods themselves appear here to be usually a little longer than in the first specimen though the longest are of the same length, and to be seated on tubercles which are stouter and less elevated, but this may be merely an appearance due to the way in which the specimen is preserved. The relation of the rods of the first and second body segments, and of the last segment to the others so far as their size and distribution is concerned, is the same as in the previous specimen; but those of the anterior segments are not directed forward, but on the first segment backward and on the second laterally so as to leave the head nearly uncovered. This appears as a rather small, transversely oval, rounded mass, about twice as broad as long, and only about half as broad as the body; neither eyes nor antennae can be made out.

The specimen obtained by Mr. Bliss (pl. 26, fig. 8) is slightly smaller than the others, preserved on a side view, and arcuate instead of straight. If extended, the length of the body would be 33.5 mm. and its height 4.5 mm.; or, including in the height both spines and legs, 13.5 mm.

The rods in the fascicles are even less divergent than in the last mentioned specimen, rarely exceeding 40° between opposite rods of the same fascicle (pl. 26, figs. 5, 9). There is also less indication here of any tubercles at the base of the fascicles, and those of the first and second segments although shorter than the others are not noticeably so, and the first are very nearly as long as the second; the longest spines are about 6 mm. long. In this side view the head again appears, not separated by any sharp line of demarcation from the segment behind, but considerably smaller than the body, higher than long, rather flattened in front, and with an inferior basal projection of a conical form; no eyes nor appendages can be made out. The legs are about as long as the width of the body, stout, slightly smaller at the immediate base than just behind it, tapering beyond the middle and with increasing rapidity nearly to the tip, the last joint apparently being equal; this is hardly shown in the plate, and does not show on all the legs in the fossil, the apices of these members being exceedingly vague; but in a few instances it appears to be somewhat clearly the case, and a slight appearance of it shows on the leg of the seventh body segment in the plate; on the reverse of the specimen drawn it appears even more plainly on the legs of the second, fourth, and fifth segments. This apical joint appears as such simply by the contour of the leg, but no other joints can be determined in the same way; indeed, the legs themselves are only pale shadows, and they are traversed by numerous darker bands which seem to indicate joints, but they are rather more numerous than one would expect, and a little irregular, so that little can be definitely affirmed concerning them; taking them, however, where they appear most regular and best defined and connecting with them the two or three transverse rows of minute granulations that seem to encircle each joint with some regularity, and it would appear as if there were about five equal joints in the leg besides the smaller non-tapering apical joint. The length of the legs appears to be slightly greater in the middle of the body than at the two extreme ends; the middle legs are 4.5 mm. long (of which the apical joint is 0.75 mm. long) and 1.1 mm. broad in the middle, the apical joint being 0.5 mm. broad. No sign of claws can be seen.

The fourth specimen, received from Mr. Carr after the others had been studied and figured, differs but slightly from the first two. It exhibits the animal expanded in a straight line, but a little on one side so that only the spines of one side show in full. The spines of the first and second segments are lateral; but, nevertheless, no head is visible, being, perhaps, buried in the stone. The spines, especially individual ones, are of unusual length, the longest being 8.5 mm. long; they diverge in the fascicles less, rarely exceeding a divergence of 35° and usually not exceeding 20°. The fascicles of the hinder half of the body trend slightly backward, increasingly so toward the tip, but they are almost exactly at right angles to the body on the front half. No legs are visible. The body is 32.5 mm. long, or including the spines which fringe the posterior end 35 mm. (perhaps more, for the end of the stone is reached); the width of the body is 6.5 mm.; or, including the mass of spines (on one side only) 12 mm.; or, including the longest spines, 14 mm.

These specimens, which agree so closely in size, are considerably larger than the first specimen found, upon which the description of the species was based by Messrs. Meek and Worthen; judging by their figure and description, that specimen if extended would measure 23 mm. in length; or, inclusive of the rods, 32 mm.; and 3.5 mm. in breadth; or, including the rods, 8.5 mm. To judge from the arcuate position and the absence of rods from the under surface, it probably presented a side view or one partially dorsal; but the authors say that neither head nor feet can be seen; the distribution of the rods is somewhat like that of our fig. 7, that is they are considerably divergent, but the figure gives no sign of any tubercles to which they are attached; the general resemblance of the whole animal is so close that no doubt can exist that it is of the same species as those now figured. The specimen has been lost by a fire.

In a later volume of the Illinois reports the original authors of the species describe another specimen from the same place, only mentioning, however, the rods, which they say are much better preserved, and which for the first time they discover to have longitudinal markings.

A careful study of the four specimens seen by me show that there is no variation in the character of the rods in different individuals beyond what is found on one and the same individual; and these may now have a particular description, which from their remarkable structure they well merit.

The rods (pl. 26, fig. 1) are straight, rigid, needle-shaped bodies, 5–6.5 mm. long and about 0.075 mm. in diameter, imperceptibly tapering, so as to be at tip fully three-quarters as large as at base, and terminating abruptly, apparently with a broadly rounded tip. It seems to be composed (pl. 26, figs. 2, 4) of an inner core, about nineteen-twentieths (in diameter) of the whole, and a shell upon which very delicate markings are traced; the shell readily peels from the central core and may thus be mounted in balsam and examined by transmitted light under the microscope (pl. 26, fig. 3), when the distinctions between the parts may be readily seen.

Two schematic drawings are given to show the minute markings of the shell. Pl. 26, fig. 4, represents a diagrammatic view of the cross section of a rod, magnified 1000 diameters, and fig. 2 represents an oblique view on the same scale. The rods are thus seen to be longitudinally furnished with about eighteen mainridges, as straight as the rod itself, equidistant from each other, rounded at the top and with steeply sloping sides so as to be scarcely broader at base than in the middle and of equal basal breadth and height; these ridges are divided at subequal distances by notches, or rather they are made up of serrations, the highest end of the serration next the tip of the spine; the greatest increment in the height of the serration is in its basal fourth, calling the base the end toward the base of the spine; and the extreme height is about double the least height; in the same basal fourth occurs the greatest increment in breadth, for each serration increases also in this dimension toward its highest point, so as to be about one-fifth broader at apex than at base. To increase the distinction of the serration, there appears at the base of each to be a closed joint, separating each one from its neighbors. Although at first these serrations appear to be divided off from each other with remarkable regularity, and at a distance apart averaging about .0133 mm., a little observation shows that this is not strictly true; and a measurement of nineteen successive serrations on the same ridge showed the following series as given in millimeters: .0144, .0135, .0182, .0144, .0135, .0115, .0154, .0115, .0173, .0135, .0135, .0115, .0144, .0135, .0125, .0115, .0077, .0115, .0135; another shorter set on another spine gave the following series: .0154, .0115, .0154, .0192, .0135, making the average a very little less.

Between every pair of these ridges are generally three, sometimes two, exactly similar but miniature ridges about one-eighth the height of the others, and also of equal height and width but apparently a little more triangular in cross section; these likewise are broken up with serrations, apparently resembling the others closely but so minute that the proportions cannot be so closely studied as to be quite sure of this; they certainly differ in that the serrations are proportionally longer, there being but two or three to each serration of the larger ridges, as shown in pl. 26, fig. 2. In this drawing, based on instruction given the artist from my studies of numerous fragments, and by his examination of the specimen represented in pl. 26, fig. 3, he has misunderstood a single point, in bringing the larger ridges nearer together in some parts of the same cross section than in others, and placing between them only two instead of uniformly three minor ridges. In all the fragments I have seen there are either two or three (almost universally three) minor ridges between every pair of larger ridges on every part of the same fragment. It is possible that in the slight tapering of the spine two larger ridges coming nearer together compel the union of two adjacent minor ridges and reduce the number to two instead of three, so that in one portion of a spine one may find two and in another three minor ridges between every pair of larger ones; but this I have not seen and can only say that while three smaller ridges usually appear in every inter-space between adjoining larger ridges, the number is sometimes only two. Otherwise the proportions of these ridges and serrations to each other is very well shown in fig. 2.

All the specimens found came from the ironstone nodules of Mazon Creek, near Morris Illinois.

Explanation of Plates.

PLATE XXVI.

[All the figures represent Palaeocampa anthrax.]

Fig. 1. A spine $\frac{30}{1}$ to show its appearance under an ordinary strong lens, showing an apparently striated surface. Drawn by Katherine Peirson.

Fig. 2. An oblique view of a fragment of the surface of the spine $\frac{400}{1}$, showing the serrations of the larger and smaller ridges and their relations to each other; three of the minuter ridges should have been shown in every interspace, but in two of them only two are given. The figure is schematic. Drawn by J. Henry Blake.

Fig. 3. A fragment drawn from nature of the shell of a spine $\frac{250}{1}$, as seen with a half-inch objective. Drawn by the same.

Fig. 4. Schematic view of a cross section of the shell of the spine, showing the relations of size and position of the spine, the shell and the two kinds of ridges, $\frac{2000}{1}$. Drawn by S. H. Scudder.

Fig. 5. One of the clusters of spines of fig. 8, $\frac{7}{1}$. Drawn by Katherine Peirson.

Fig. 6. One of Mr. Carr's specimens, showing the head, above, $\frac{2}{1}$. Drawn by the same.

Fig. 7. The other of Mr. Carr's specimens, $\frac{2}{1}$. Drawn by the same.

Fig. 8. The specimen with legs, found by Mr. Bliss, $\frac{2}{1}$. Drawn by the same.

Fig. 9. The same cluster of spines shown in fig. 5, $\frac{4}{1}$. Drawn by the same.

PLATE XXVII.

Fig. 1. *Trichiulus nodulosus*, $\frac{2}{1}$. From the collection of Mr. P. A. Armstrong, No. 7. Drawn by Katherine Peirson.

Fig. 2. *Trichiulus villosus*, $\frac{3}{1}$. From the same collection, No. 18. Drawn by the same.

Fig. 3. *Trichiulus nodulosus*, $\frac{2}{1}$. From the same collection, No. 52. Drawn by the same.

Fig. 4. *Trichiulus ammonitiformis*, $\frac{2}{1}$. From the same collection, No. 2. Drawn by the same.

The remaining figures belong to the next memoir.

X. The Species of Mylacris, a Carboniferous Genus of Cockroaches.

By Samuel H. Scudder.

Read May 24, 1882.

Mylacris was first suggested by me as a name for a genus of paleozoic cockroaches in 1868, but its full definition from other cockroaches was not given until eleven years later in my memoir on paleozoic cockroaches, when five species, two of them new, were fully characterized and figured. It is the principal genus of the tribe Mylacridae, the distinctively American group of ancient cockroaches, and by the facts known three years ago appeared to be confined to the lower or middle coal measures. Through the indefatigable efforts of Mr. R. D. Lacoe of Pittston, Penn., whose explorations of the coal measures of the United States have yielded better results for fossil insects than those of any other person, I am enabled in this paper to double the number of species, besides giving additional information concerning an imperfectly known species, nearly all the additional forms coming from the coal measures of Pennsylvania; not all, however, as before, from the lower and middle series, but also from the upper coal measures, showing that Mylacris has the same range as Lithomylacris. The species of the genus may be distinguished by the following table.

Key to the Species of Mylacris.

1. Externomedian veins superior or apical. — 2
1. Externomedian veins inferior or apical. — 7
2. Externomedian veins distinctly superior. — 3
2. Externomedian veins rather apical than superior. — 5
3. Apex of wing falling in the middle line, the costal and inner margins being about equally arcuate. — 1. *M. bretonensis.*
3. Apex of wing falling below the middle line, the inner margin being much straighter than the costal. — 4
4. Costal margin curving inward on the basal third of the wing. — 7. *M. anthracophilum.*
4. Costal margin bent abruptly inward at extreme base of the wing with no previous inward curve. — 8. *M. priscovolans.*
5. Externomedian area occupying the apex of the wing. — 2. *M. Heeri.*
5. Externomedian area falling wholly below the middle line of the wing. — 6
6. Mediastinal veins comparatively few and distant; scapular vein forked at base. — 3. *M. antiquum.*
6. Mediastinal veins numerous; scapular branches all emitted from a single main branch. — 4. *M. lucifugum.*
7. Costal much more curved than inner margin. — 8
7. Costal and inner margin similarly and symmetrically curved. — 9
8. Costal margin very strongly curved in the mediastinal area, which scarcely reaches to the middle of the wing. — 6. *M. carbonum.*

8. Costal margin gently curved in the mediastinal area, which extends considerably beyond the middle of the wing.
5. *M. pennsylvanicum.*

9. Combined mediastinal and scapular areas as broad at the base as beyond.
9. *M. Mansfieldii.*

9. Combined mediastinal and scapular areas much broader near the middle of the wing than at the base.
10. *M. ovale*

1. **Mylacris bretonense.**

Blattina bretonensis Scudd., Can. Nat., VII, 271–272, fig. 1. Figured also in Dawson's Acadian Geology. Suppl. to 2d ed., p. 55. fig. 5.

Mylacris bretonense Scudd., Mem. Bost. Soc. Nat. Hist., III, 41–42, pl. 5, fig. 1.

Sydney, Cape Breton.

2. **Mylacris Heeri.**

Blattina Heeri Scudd., Can. Nat., VII, 272, fig. 2. Figured also in Dawson's Acadian Geology. Suppl. to 2d. ed., p. 55, fig. 6.

Mylacris Heeri Scudd., Mem. Bost. Soc. Nat. Hist., III, 43–44, pl. 5, fig. 11.

Sydney, Cape Breton.

3. **Mylacris antiquum**, nov. sp.

Front wing. The inner edge is imperfect and a little of the tip is gone, but the rest of the wing, which is remarkable for its approach to Lithomylacris, is pretty well preserved. The mediastinal and scapular areas together certainly occupy the major part of the wing and the externomedian area expands but very little apically; the wing, however, is broad and full and closely approximates *M. Heeri.* The humeral lobe is full and angular, with the corner well rounded off, the costal margin scarcely convex beyond the base; the whole wing was probably a trifle more than twice as long as broad. The veins originate from a little below the middle of the base and curve upward at their start until they reach the middle, when they are very nearly straight. The mediastinal area is very large indeed with few and rather distant veins, forking once near the base, reaching the end of the middle third of the wing. The scapular area occupies the rest of the upper half of the wing, the vein itself dividing close to the base, the forks again dividing near together in the basal third of the wing, with a still further branching of nearly every ramus half way to the tip, and again of some near the tip; these branches are all straight except the lowest near the tip which turn slightly upward, thus throwing all the extremities of the branches above the middle of the tip and giving the scapular-externomedian interspace a slight sinuosity. The externomedian vein is straight and forks first just before the middle of the wing; each of its branches dichotomizes more or less but without much further divarication, so that the area is more crowded with veins than those above. The internomedian area is tolerably large, notwithstanding the considerable size of the anal area, for it reaches well toward the extremity of the inner margin of the wing, sweeping thither in a somewhat sinuous curve with unusually longitudinal veins; in the single specimen the vein has but three branches, the middle one forked near its origin, the others simple. The anal area is very large, the anal furrow being very pronounced, broadly curved and extending far outward in a somewhat unusually longitudinal course nearly to the middle of the wing; the anal veins appear to belong to two sets opposed to each other, an upper with inferior, and a lower with superior branches, all very longitudinal, nearly parallel with the costal margin and nearly all simple; the upper area is just as longitudinal as the lower and quite independant of the course of the furrow, leaving a large subtriangular space near the most strongly curved portion of the furrow quite devoid of veins.

The species is a very large one, the largest of the genus yet known; the fragment of the wing being 33 mm. long (its probable entire length 37 mm.) and its breadth about 17.5 mm.; or, the breadth to the length as about 1 : 2.1. All the veins are in very distinct relief, with the interspaces deeply sunken between them; there seem to be no surface markings. The specimen is curiously preserved, the edge of one-half of the nodule falling longitudinally across the inner margin, following nearly the mid-space between the two sets of anal veins as marked by the light belt in the larger figure we shall hereafter give; all the parts below this, together with the opposite left wing (given in the other figure) lie over the edge on the back side of the stone, the plane of which lies at an angle of about 45° with that showing the main portion of the right wing, and forms the present surface of the nodule; the other half of the nodule shows the counterpart of our larger figure.

This species is, as we have said, most nearly allied to *M. Heeri* in the great amount of space occupied by the mediastinal and scapular areas as well as by the course of the anal furrow, and apparently by the peculiarities of the anal veins. It is, however, a very much larger species than it (or any other species of Mylacris), and the peculiar dichotomous division of the scapular vein separates it at once from every species known, and it is nearly as peculiar for the longitudinal course and sinuous sweep of the internomedian veins. In the general positions occupied by the different areas, it resembles *M. lucifugum*, with which it better agrees in size; but it disagrees with it, not only in the peculiar division of the scapular vein, but in the less crowded and more regular veins of the mediastinal area, and the more rounded humeral lobe.

The specimen comes from the famous locality of Mazon Creek, and is in the collection of Mr. R. D. Lacoe under the number 2036. Having been received after the plate was engraved, figures of the species will be given on some future occasion.

4. **Mylacris lucifugum** nov. sp.

Pl. 27, fig. 8.

Front wing. The basal portion, excepting the anal area, is preserved, but at least the apical third is gone. There is a rectangular rounded shoulder of considerable extent, minutely marginate, but without neuration; the basal, preserved half of the costal margin is straight, but at the extremity of the fragment begins to curve slightly, and this with the direction of the veins makes it probable that beyond this it was gently arcuate, the tip rounded and the inner margin nearly straight. The mediastinal veins are confused at their base by vegetable remains and may be inaccurately given in the plate, but they apparently occupy the area marked, or more than one-third of the fragment and nearly one-fourth of the wing; they diverge from a point before the base of the wing and are very straight and fork somewhat — just how much the preservation does not permit one to say. The scapular vein passes in a very straight course down the middle of the wing with a slight obliquity from above downwards in passing distally, but probably terminates at the apex; it emits a number (4 or 5 are preserved in the fragment) of straight, approximate, so far as we can see simple, branches parallel to the mediastinal veins. The externomedian vein is slightly arcuate, but otherwise parallel to and equidistant from the scapular, forks before the middle of the wing, each of these branches again forking, but not widely; in the part lost they probably branch more but can hardly occupy much space on the border. The internomedian vein is gently and uniformly arcuate and probably terminates where the inner margin begins to curve considerably toward the tip; in the basal half of its course it emits four or five simple, occasionally simply forked branches, more faintly traced than the other veins of the wing and which curve gently in an opposite sense to the main stem. The anal furrow is slight and faintly impressed, gently and regularly curved throughout, terminating probably at the middle of the wing; the anal veins are not preserved.

The species is a large one, the fragment being 22 mm. long, while the entire wing can hardly have been less than 33 mm. long, and its breadth, which is preserved, is 15 mm., making the breadth to the probable length as 1 : 2.2. The veins are slightly elevated and distinct and regular. There appears to be no reticulation or cross venation whatever, and the surface of the shoulder of the wing is particularly smooth.

The species appears to be most nearly allied to *M. Heeri*, but it is much larger than it, or, indeed, than any other species of the genus, except the preceding, and its anal furrow is even more longitudinal and less arcuate than in *M. Heeri*; it differs also from the latter in the much greater number and closer approximation of the mediastinal nervures and in the downward sweep of the externomedian veins, probably causing the area to occupy the margin wholly below the apex of the wing. In the stout square humeral lobe of the wing, in which the veins are obliterated, it seems to be peculiar, as it is also in the regularity of the curve of the anal furrow.

The single specimen upon which the species is based was found by Mr. R. D. Lacoe at Port Griffith Switchback, near Pittston, Penn., and bears the No. 2017 in his collection.

5. **Mylacris pennsylvanicum.**

Pl. 27, fig. 11.

Mylacris pennsylvanicum Scudd., Mem. Bost. Soc. Nat. Hist., III, 44–45, pl. 5, figs. 13–14.

A second specimen of this species enables me to supplant the previous description from an imperfect specimen by a better; the present specimen is also imperfect but makes up in part what the other lacks.

Fore-wing. The distal extremity is lost in each, but more of the costal is preserved in the new specimen, while the inner margin is almost completely lost in both; the form of the wing can nevertheless be judged with probable accuracy; the course of the veins indicates a shorter and stouter, as it certainly is a broader wing than in *M. Heeri*. The humeral lobe is prominent, its straight basal side bent at nearly a right angle with the arcuate costal edge, the angle rounded off; the costal margin is considerably arcuate, more strongly at extreme base and beyond the middle than in the intermediate straighter portion where the arcuation is very gentle; in this respect the figure previously given is slightly inaccurate. The course of this margin with the breadth of the wing and the direction of the veins render it probable that the rest of the wing had the form given in the dotted lines in the figure, in which the apex of the wing falls within the middle line, and slightly changes the form from what was given before, and which we had already noticed as probably not correct. The veins originate from the middle of the wing and curve a little at the base. The mediastinal area has a basal width of very nearly half the wing, and, separated from the scapular by a scarcely curved line, strikes the costal margin at about the end of the second third of the wing (in one specimen probably a little less than that, in the other probably a little more); the basal part of the costal margin is very narrowly and delicately marginate; the part of the mediastinal area next the humeral angle is not veined, but below it are four or five scarcely curving, long, gently diverging, simple or deeply forked veins; the middle ones simple (possibly united nearer the base, where they are not sufficiently preserved to see it), the others forked. The scapular vein is gently and broadly sinuous and probably terminates just above the apex of the wing; in the basal part of its course it runs closely parallel to the costal margin and a little nearer to it than to the inner margin; in the latter half or more it curves in an opposite sense to the costal margin; it commences to branch very near the base, and emits four or five branches, simple or forked, rarely compound, long and nearly straight, having the same direction as the outer mediastinal veins; in one specimen the basal, in the other the apical vein is compound, the rest generally simple. The externomedian vein is somewhat arcuate until it divides, a little beyond the basal third of the wing; both these branches again divide scarcely beyond the middle of the wing, the uppermost again forking not long after; probably they fork more, and, as in the central part of the wings, fill their area with dichotomizing veins whose general direction is nearly longitudinal, with a slight downward tendency, but closely approximated, so that on the edge the veins occupy a narrow area mostly below the apex of the wing. The internomedian runs in a broadly sinuous course parallel to the preceding vein, probably strikes the lower margin where the wing begins rapidly to narrow, and emits four or five, perhaps more, simple or basally forked, indistinct, arcuate branches, which occupy upon the inner margin about as much space as the scapular upon the costal margin. The anal furrow is strongly impressed upon its basal half or more, less so but still distinctly beyond, is composed of a pair of closely approximated fine grooves, and is regularly and not very strongly arcuate, terminating on the inner border at some distance before the end of the mediastinal area, at just about the middle of the border; the anal veins are numerous and closely crowded, nearly all simple, and all slightly arcuate.

It is a tolerably large species, the breadth of the wing being 13.5 mm. and its length probably 26 mm.; or, its breadth to its length about as 1 : 2; the actual length of one fragment is 19 mm., of the other 20.75 mm.; the condition of the first is mentioned in the former description of the species; the second specimen is represented both by that drawn and by its reverse; in the one drawn the veins are in relief and the figure represents, therefore, the under surface of a right wing (or a cast of the opposite) in which, as in the individual previously described, slight indications of transverse wrinklings may be seen here and there and especially in the scapular area, but there could have been no regular or definite reticulation.

The species differ from *M. Heeri*, its nearest ally, in the stronger curvature of the anal furrow, and in the greater width of the anal area but not in its greater abbreviation, as previously stated, the breadth of the area making up for the greater curvature of the furrow; it also differs, as before stated, in the sinuosity of the scapular vein, the more arcuate line of separation between the mediastinal and scapular areas, and the more crowded branches of all the areas but the internomedian; the wing as a whole is also proportionally broader.

The new specimen comes from the same bed as the last, and was sent me by Mr. R. D. Lacoe of Pittston, in whose collection it bears the number 2024. It occurs on the same stone as *M. carbonum*.

6. **Mylacris carbonum** nov. sp.

Pl. 27, figs. 6, 7, 10.

Fore-wing. The greater part of the wing is preserved, but the apical fourth or fifth of the tip is missing as well as a patch along the inner margin from the tip to the anal area. From what remains, the wing had probably a form somewhat like that of *M. anthracophilum*, but was not quite so tapering, the costal margin being a little less convex; the inner margin next the anal area was straight. The veins originate from the middle of the wing, but do not curve at the base. The mediastinal area has, therefore, a basal width of half the wing and extends to beyond the anal, or probably to just about the middle of the wing: in the humeral portion of the area no veins can be made out, but in the opposite half two compound veins can be seen, the first consisting of a pair of simple veins united basally, the second of a pair of forked veins united basally very near the extreme base of the wing: both of these veins are forked about midway in their course, the outer twice, close together. The scapular vein can only be traced basally to where it begins to curve inward, a little beyond the forked mediastinal vein just described; it, together with the next vein in close juxtaposition, curves strongly but only for a very short distance, and the curve of the anal furrow would seem to preclude any further continuation of the curve, so that in reaching the base of the wing it must resume its outer course; beyond this basal curve it is straight and must strike at the apex of the wing, though it cannot be traced throughout; in the fragment it has five equidistant branches, and probably has a couple more before the tip; the third of these is forked not far from the base, but all the others, so far as seen (excepting the first) are simple and straight, although very long, for the straight main vein runs sub-parallel to the costal margin scarcely above the middle line of the wing: the first branch, however, differs from the rest; it originates where the main vein begins its straight course, and continues the direction of the deflected basal part of the vein, and emits from its apical side three long, straight, equidistant offshoots, the first from its very base, the last half way to the margin. The externomedian runs in a straight line scarcely below the middle of the wing and first divides a little before the middle, and in the fragment has three simple slightly curved branches, their convexities toward the anal area, and their bases considerably further apart than the scapular branches. The internomedian runs parallel and close to the externomedian vein and its basal branch, probably reaching the inner margin more than half-way from the anal furrow to the apex; it commences to divide as soon as there is space for it opposite the middle of the anal furrow, the first branch forking, and the second branch originating next the first branch of the externomedian vein; a third branch springs at a similar distance further on, but more cannot be seen. The anal furrow is tolerably distinct, curved gently throughout and bent a little in the middle, terminating at more than one-third of the distance toward the tip, or about opposite the first divarication of the externomedian vein; the anal veins are exceedingly numerous and crowded, many of them forked, some of them doubly, generally near the middle of their course; those next the anal area are obliterated, but if they retained the character of the remaining part of the area, about twenty veinlets must have impinged upon the outer margin in the anal area; those lying next the angle of the wing have a sinuous course, changing to a simple gently arcuate curve toward the anal furrow.

This fragment represents a species of tolerably large size, the breadth of the wing being 13.5 mm., the length of the fragment 23 mm., and the preserved length of the wing about 27 mm.; so that the breadth to the length must have been as 1 : 2. It is the under surface of a right wing, all the veins and the anal furrow being in relief and, with the exception of the anal veins and the internomedian branches, somewhat prominent. No trace of reticulation or transverse wrinkling can be seen.

The specimen occurs on a piece of black carbonaceous shale with reeds at Cannelton, Penn., and was sent me by Mr. R. D. Lacoe with the number 2022 a.

After the above description was prepared two other specimens came into my hands through the indefatigable exertions of the same friend. As they are less perfect than that already described, the points in which they vary from it may best be pointed out by separate description.

The first, No. 2022 b, c, occurs in duplicate on the same stones with No. 2021, *M. pennsylvanicum*, and was found at Cannelton, Penn., in the same shales as that which yielded the type. It preserves a middle fragment of the wing, with a portion of the costal margin only, and a minute bit of the inner margin; no part of the wing appears which is not seen in the type, unless it be a little more of the externomedian vein. It is a little smaller than that specimen, its width at the end of the basal third of the wing being 11 mm., where in the other specimen it is fully 13 mm. In 2022 b, c, all the mediastinal veins are straight and simple as far as they can be seen, so that they do not divide beyond the base, giving this area a very different appearance from what it has in 2022 a. The scapular vein, although extending on the fragment as far toward the apex as in 2022 a, has only three branches, the outer two simple so far as they can be seen, the basal, however, dividing at its very base into two forked branches, the upper fork of the upper branch again dividing; this is somewhat different in description from the condition in 2022 a, but is really much the same as if the second offshoot of the first branch were united to the first offshoot and they together arose in the axilla of the first branch. The externomedian vein also differs somewhat and reminds one rather of the arrangement of that vein in *M. pennsylvanicum.* It commences to divide at the same point, but instead of two or three simple inferior branches with a tolerably good expansion it forks narrowly in a longitudinal fashion, and each of its forks simultaneously divide in a similar way a little further on. Below this the wing is not well preserved, but the veins that do show do not appear to differ from the type.

The second additional specimen, No. 2022 d, comes from a different locality, the Empire Mine at Wilkesbarre, Penn., and was found at the horizon of the E. vein on a piece of gray shale filled with remains of ferns, etc. This specimen, excepting in the internomedian area, preserves also no part not found in 2022 a; it is of the same size as it, measuring fully 13 mm. in width at the same point; the basal half of the costal border (excepting the humeral angle) and a fragment of the inner margin beyond the anal furrow are preserved; the costal margin is represented as perhaps too convex in the figure, where it should correspond very closely to 2022 a. The veins of the mediastinal area are better preserved than there and resemble their disposition more closely than that of No. 2022 b, c, being compound or two-forked away from the base, while in 2022 b, c, they are all simple; they diverge from one another more widely than in 2022 a, and those toward the humeral angle are simple, distant and incomplete. The scapular vein agrees very closely with its disposition in 2022 b, c, differing only in having an additional branch in the same space, in which it agrees more closely with 2022 a, and in having the axillary branch simply forked instead of compound. The externomedian vein does not agree with either of the other specimens; its main stem runs closely parallel to the scapular and has only one branch, which is emitted in a similar position to that of the first branch in the others; this branch, however, is compound, its upper fork dividing, and the whole area which it appears to occupy, in the lost part of the wing, as broad as in 2022 a. The internomedian area appears to be exactly as in 2022 a, but as a general thing only the terminations, while in 2022 a only the bases, of the veins can be seen; the fragment of the inner border at their tips is straight. The anal furrow appears to be more gently and regularly curved than in 2022 a, but the difference is slight. No anal veins are preserved.

The differences between these specimens, although considerable, do not seem to be more than individual and strengthen rather than weaken the validity of the other species of the genus, and support the distinctions upon which they have been separated from one another.

This species, peculiar for the excessive crowding of the veins in the anal area, falls in its general features between *M. pennsylvanicum* and *M. anthracophilum.* From the latter it differs in that the veins do not curve downward at the extreme base of the wing, but have a sinuous course, the greatest curve being nearly as far out as the middle of the anal area; in the simplicity of the scapular veinlets and the composite character of the first branch; and in the crowded condition of the anal veins in contrast to the comparative openness of the neuration elsewhere, nearly all the nervules being long and simple, while in *M. anthracophilum* nearly all are forked about the middle. From *M. pennsylvanicum*, which comes from the same general locality, it differs in its more tapering form, due to a greater convexity of the costal margin; in the straighter course of the scapular vein, the more gentle sweep of the anal furrow allowing a much narrower space for median veins, which in *M. pennsylvanicum* first divaricate at the same point, but here, notwithstanding the narrowness of the space, the internomedian first forks between the first and second branches of the scapular, while in *M. pennsylvanicum* only opposite the base of the third branch; the anal veins are also much more numerous in the present species.

7. Mylacris anthracophilum

Mylacris anthracophilum Scudd., in Worth., Geol. Surv. Ill., III, 568–570, figs. 5, 6. — Ib., Mem. Bost. Soc. Nat. Hist., III; 15–17, pl. 5, figs. 6–8.

Colchester, Ill.

8. Mylacris priscovolans

Pl. 27, fig. 9.

Fore-wing. A bit of the extreme tip and a considerable part of the wing next the inner border is wanting, although the position of the margin itself is indicated by a depressed line upon the stone, showing the form of the wing to have closely resembled that of *M. carbonum*, being broadest at the extreme base, narrowing toward the apex with increasing rapidity, so that the inner margin being straight, the costal margin is considerably curved; the tip, though narrow, is broadly rounded, and lies within the median line of the wing; the humeral lobe is very square, rounded only at the extreme angle. The mediastinal area is of a very regularly triangular form, one-third the width of the wing at the base, and apically extending considerably beyond the middle of the distal half of the wing; its three or four veins fork near the base, and extend their long, simple, or branching rays far out to the margin. The scapular vein is rather strongly curved near the base, beyond which it sweeps with a very slight opposite arcuation, subparallel to the costal margin to the very tip of the wing; its four or five long and mostly simply and deeply forked branches have a completely longitudinal course, and the area forms a triangle of about the same size and regularity as the mediastinal area, but with an opposite disposition. The externomedian vein passes with a curve similar to, but stronger than that of, the scapular vein, diverging from it, and terminating on the inner margin beyond the middle of the outer half of the wing; but within the extremity of the mediastinal vein, its long, arcuate, simple, or simply forked branches being superior. The internomedian vein is again curved in the same sense as the externomedian and has about four simple or forked arcuate branches. The anal furrow starting from above the middle of the wing is deeply impressed, regularly and considerably arcuate, but more strongly curved in its basal than its apical half, and terminates at the middle of the inner margin; the anal veins are oblique or arcuate, simply forked or compound, somewhat irregular and hardly more crowded than the internomedian veins.

The species is a large one, the wing measuring 26.5 mm. in length by 14.5 mm. in breadth, the breadth being to the length as 1 : 1.8; the continuous part of the fragment is 25 mm. long and 12 mm. broad at the base. The wing is a right one, the under surface (or cast of the upper) having been figured, and the veins are distinctly and sharply impressed; no sign of cross venation or of any reticulation appears. The wing is peculiar for its excessive breadth at base combined with its square-shaped humeral lobe, which causes it to taper from the very base; it is nearly allied to *M. carbonum* and *M. anthracophilum*, differing from both in the peculiarities just noted, as well as in the less produced and more fully rounded apex, and the considerably greater extent of the mediastinal area; the veins of the anal area are less crowded and less regular than in *M. carbonum*, and the externomedian branches are superior instead of inferior; hence it agrees better with *M. anthracophilum*, but the externomedian vein lacks the basal branch found there and the anal veins are not so regularly disposed; the much less strongly curved costal margin is dependent upon the basal breadth of the wing, already mentioned.

The specimen figured is numbered 2031 a. in Mr. Lacoe's cabinet, and its reverse No. 2031 b. It comes from Cannelton, Penn.

9. Mylacris Mansfieldii.

Mylacris Mansfieldii Scudd., Mem. Bost. Soc. Nat. Hist., III, 47, pl. 5, fig. 15. Cannelton, Penn.

10. Mylacris ovale nov. sp.

Pl. 27, fig. 5.

Fore-wing. The anal area and the extreme base of the wing is absent, but the larger part of the wing is entire with perfect margins except an unessential fragment, showing the wing to have been a little more than twice as long as broad, very regularly oval, with similar and symmetrical costal and inner margins and a rounded subacuminate tip. It is peculiar for the basal narrowness of the mediastino-scapular area. The mediastinal area is very small though reaching beyond the middle of the wing for next the base it is not more than one-fifth the width of the wing and begins to narrow opposite the end of the anal furrow; its veins are only two or three in number, simple or forked, very gently arcuate and subparallel, the limitation between the mediastinal and scapular areas being arcuate in a sense opposed to that of the anal furrow. The scapular vein has a considerably arcuate course throughout; starting so as to be fairly within the upper fourth of the wing, it curves first downward and then upward with a regular sweep which includes two-fifths of the wing in the middle, and terminates just above the apex of the wing; it emits in this specimen four branches, gently arcuate in the same sense, simple, singly or doubly forked, all but one of which are thrown off in the basal third of the wing, not very far apart. The externomedian vein has an arcuate course in the same sense as the preceding, running in the outer half of the wing subparallel to the inner margin; it commences to divide before the end of the anal area and emits four inferior equidistant branches, the last opposite the end of the mediastinal area, the extreme ones simple, the middle ones simply or doubly forked, all considerably curved in the same sense as the main vein, at least at their base. The internomedian vein curves again in the same sense, taking no curve toward the inner margin until close to the tip, and reaching the margin farther from the apex of the wing than the scapular vein, so that the larger part of the externomedian area is below the apex; it emits half a dozen or more very long, simple, or simply forked veins, all arcuate in the same sense, though more gently; three of them arising near the base far within the tip of the anal furrow, three other near the middle of the wing at no very great distance apart, and probably an apical one. The anal furrow is lightly impressed, very slightly arcuate and probably terminates before the end of the basal third of the wing. No anal veins are preserved.

The species is a large one, the fragment measuring 24.5 mm. long and 12 mm. broad; probably the entire length was not less than 28 mm., and the breadth to the length as 1 : 2.3. The wing is a right one, of which the under surface is shown in the figure and the upper in its less complete counterpart. The veins are distinctly marked, and somewhat prominent on the under surface, excepting those of the internomedian area and all the veins in the apical fourth of the wing; no cross veins or reticulation can be discovered.

This species agrees with *M. Mansfieldii* in its form and size and in the inferior origin of the externomedian branches, but it differs decidedly from it, as well as from all other species of the genus, in the sweep of the mediastinal and scapular veins, as well as in the exceedingly restricted area they cover in the basal part of the wing.

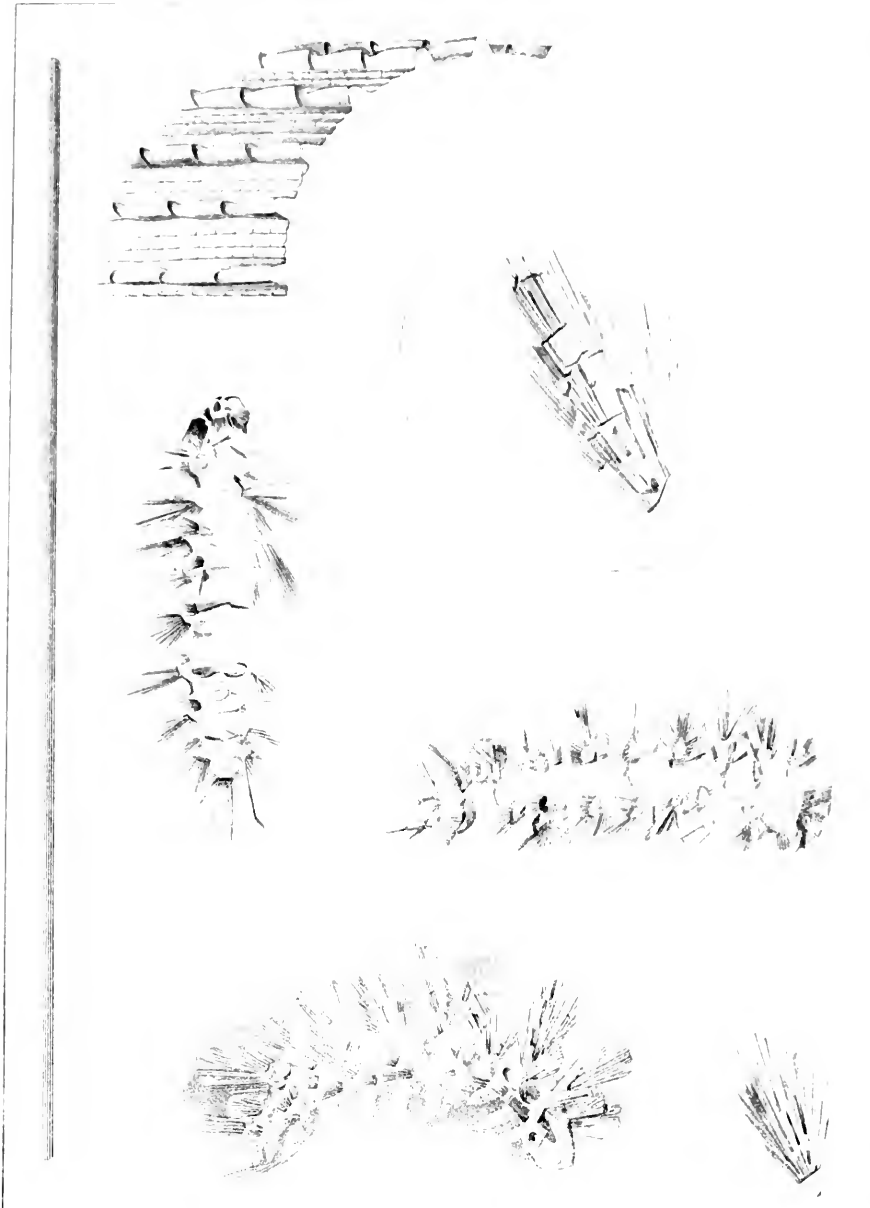
The specimen comes from Cannelton, Penn., and was kindly communicated by Mr. R. D. Lacoe, in whose collection it bears the No. 2035.

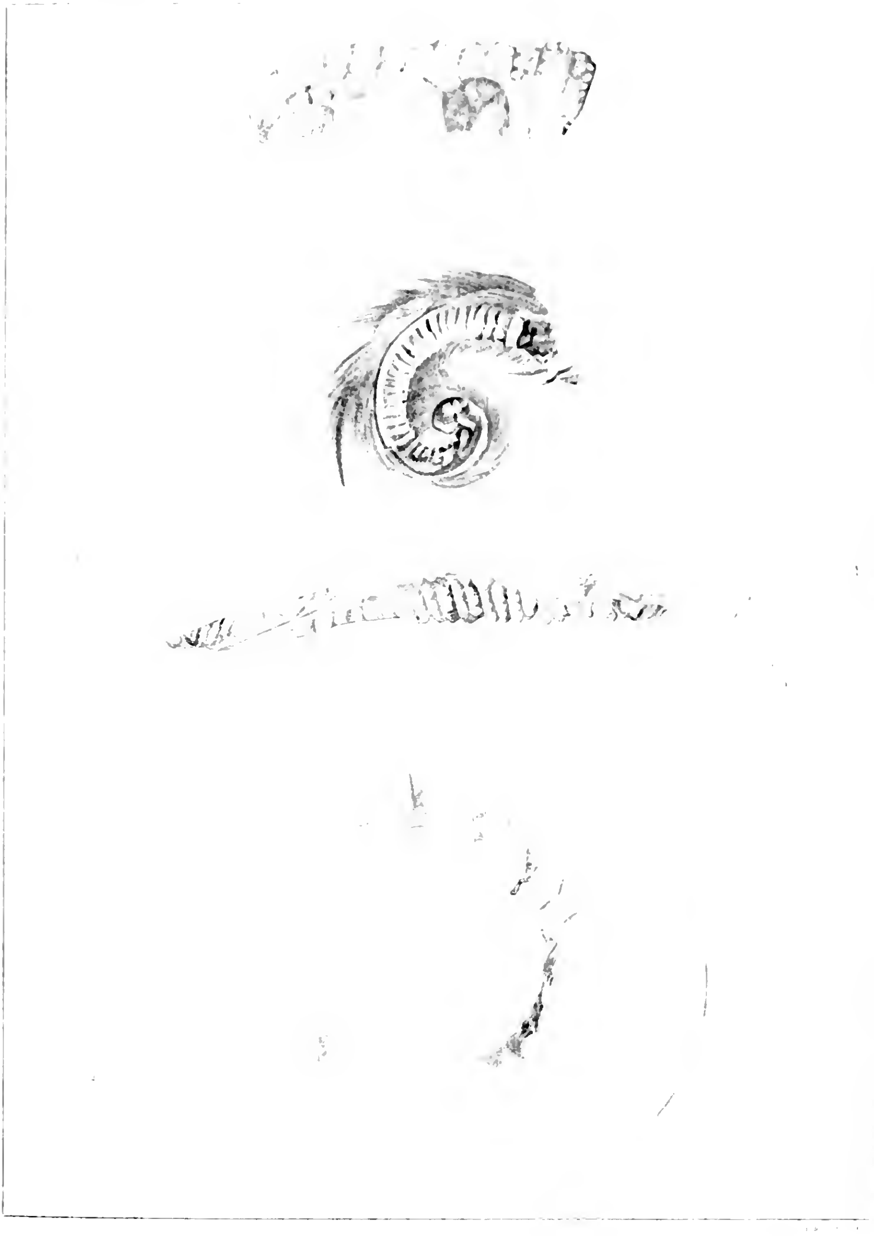
Explanation of Plate XXVII.

[All the specimens are from the collection of Mr. R. D. Lacoe.]

Fig. 5. *Mylacris ovale*. $\frac{3}{1}$. No. 2033. Drawn with camera lucida by S. H. Scudder.
Fig. 6. *Mylacris carbonum*. $\frac{2}{1}$. No. 2022 *b*, from Cannelton. Drawn by J. S. Kingsley.
Fig. 7. *The same*. $\frac{3}{1}$. No. 2022 *d*, from Wilkesbarre. Drawn by the same.
Fig. 8. *Mylacris lucifugum*. $\frac{3}{1}$. No. 2017. Drawn by the same.
Fig. 9. *Mylacris priscovolans*. $\frac{3}{1}$. No. 2031. Drawn by the same.
Fig. 10. *Mylacris carbonum*. $\frac{2}{1}$. No. 2022 *a*, from Cannelton. Drawn by the same.
Fig. 11. *Mylacris pennsylvanicum*. $\frac{3}{1}$. No. 2024. Drawn by the same.

The other figures belong to the preceding memoir.





XI. Notes on the Peeping Frog, Hyla Pickeringii LeConte.

By Mary H. Hinckley.

(Presented October 3, 1883.)

Hylodes Pickeringii Holbr. N. Amer. Herp., vol. iv., p. 135, pl. 34. *Hylodes Pickeringii* Nichols, Journ. Essex Co. Nat. Hist. Soc., No. 2. *Pickering's Hylodes* Storer, Report on Rept. Mass., p. 240. *Hyla Pickeringii* LeConte, Proc. Ac. Philad., vol. vii., p. 429, 1854. *Hylodes Pickeringii* DeKay, New York Fauna, p. 69, fig. 51. *Acris Pickeringii* Günth., Brit. Mus. Cat. Batrachia Salientia, p. 71. *Hyla Pickeringii* Boulenger, Brit. Mus. Cat. 1882, p. 399.

Description.

Adult. Head moderate in size, as broad as long, about two-fifths length of body for male, a little less for the female. Muzzle somewhat pointed, and projecting beyond mouth opening; canthus rostralis distinct; loreal region somewhat concave; nostrils nearer tip of snout than eye; pupil horizontal, when partly dilated shows angle at the base; tympanum small and indistinct; tongue heart-shaped, free behind; teeth in two small rather oblique groups, back of inner opening of nostrils. Male with dark colored vocal sac, outside muscles of throat. Arm longer than tibia, thick in males; fingers free, first short. The hind limb being brought forward the heel reaches the eye; tibia a little longer than thigh; heel and toes a little more than half as long again as the tibia; feet less than half-webbed; tubercles under hands and feet moderate; two metatarsal tubercles, outer small and obscure; tips of fingers and toes dilated into moderate sized disks. The skin is either smooth or minutely granulate above; beneath granulate; a fold across the chest. Coloration in variable shades of brown above, dotted with darker and with irregular lines not always symmetrical, frequently an x-shaped marking on the back; a dark brown streak from tip of snout through the eye to about the middle of the side of body; generally a dark band or chevron between the eyes; limbs cross-barred; beneath dull creamy-white, female sometimes with a few spots of brown or dusky on throat and chest; region of groin often yellow. Iris reddish, especially when frog is excited.

Average length of a number of full-grown males 24 mm.; females a little longer, when fully grown, than males.

Tadpole. Length of head and body about twice the width of the latter. Head broad, snout large and blunt; eyes prominent; pupil rounded or tending to more or less of an angle at base; nostrils large, nearer the eye than end of snout; distance from one another about equal to their distance from eye. Mouth broad (fig. 2), upper lip curving upward in the middle, edge even or elongated into scallops or points, fringed with deep-brown, horny teeth, as is also the divided fold beneath it and the two folds across the under lip; the under lip shows variability in the presence or absence of a short space of fringe set in the papillose border of the lip, and when the fringe is present its position and size vary; sometimes it is reduced to one or two teeth attached to about the same number of papillae. The papillae across the border of the under lip are placed either in a single or double row; if double and the fragment of a fringed fold is present, I have found the latter inserted among the papillae of the inner row. The teeth forming the fringe in the mouth are composed of a series of teeth placed one above the other (fig. 3); the base of each tooth is inverted cup-shaped, the upper edge or rim dentate; two[1] teeth or a double tooth occasionally appears in the series (fig. 4). The beak is prominent, deep-brown in color; edge of upper and lower mandible dentate. Spiraculum on the left side, opening nearer the base of tail than end of snout. The tail measures about twice the length of head and body; the membranous portion of the tail is divided into two pretty equal parts by the muscular portion which runs to a fine point. A suture or band runs the length of abdomen from branchial cavity to end of body. Head, body, and tail are traversed by glandulous lines more or less distinct; those termed "dorso-latérales" by M. F. Lataste (Étude sur le *Discoglossus pictus*; Actes de la Soc. Linn. de Bordeaux, vol. xxxiii, 4 sér. t. iii, p. 313) are most constant in presence and disposition. The tadpole leaves the membranous shell of a pale yellow color, dotted with deep-brown on head, body, and tail (fig. 1). During the first few days the brown pigment cells gradually increase, generally leaving intact a narrow space of yellow from before the eye down each side to the base of the tail; at the same time a few spots of gold-colored pigment appear on head, body, and tail. By the eighth day numerous groups of deep-brown, almost black, pigment cells have spread over the upper surfaces, excepting in some instances the narrow space of yellow, which retains its original color till the golden pigment, which gradually increases on the tadpole, forms here for a while a conspicuous line, broad and noticeably brilliant, each side the base of the tail; across the upper edge of this member lines of the same color sometimes occur. With the budding of the legs (third stage of Dugès), the gold-colored pigment begins to show a brilliant sheen of green; that of the iris, however, tends to the reddish hue found later in the fully developed eye of the frog; as much of the eye as is seen outside the iris, is of a greenish color. The vivid green sheen gives the tadpoles a prevailing tone of that color, excepting on the lower portion of the sides of head and body, where there is a roseate hue; the dorsal surface has a bluish gloss. The tail is more or less flecked with brown and black. By

[1] M. Van Bambeke. Bull. de l'Acad. Royale de Belgique, xxvi, [illegible]47, pl. i et ii. Recherches sur la structure de la bouche chez les têtards des batraciens anoures. "Rien de plus curieux que la manière dont les dents de chaque série se comportent entre elles; la dilatation en entonnoir du crochet faisant saillie sur le bord libre de la lèvre, coiffe le corps du crochet suivant; le gaine de celui-ci reçoit a son tour le corps du troisième appendice, et ainsi de suite."

the aid of a magnifying glass the upper surfaces of the body and the tail are seen to be overspread with a broken network of fine, deep brown, or black lines. The branchial cavity is more or less pigmented with the colors of the upper surfaces; the abdomen is silvery white. Entering the fourth stage of Dugès, which begins when the arms are thrown out and ends with the resorption of the tail, the greenish sheen gradually disappears and the skin develops the color and texture of the frog. Tadpoles of the same age vary in size, even when grown under the same conditions; when these are favorable, however, they measure 30-33 mm. from tip of snout to that of tail, on reaching the limit of their size.

Habits.

H. Pickeringii is the most abundant of the frogs found in Milton, Mass. With *R. sylvatica*, the wood frog, it is the last species to become silent and retire from the surface in autumn, and with that species responds earliest to the mild temperature of the variable New England spring. The piping is not general, nor heard first at the water. The frogs passing the winter in favorable situations on the land give voice earliest as well as continue it latest, for the notes of *Pickeringii*, although most emphatic then, are not confined to the mating season. In the first mild days when the mercury reaches 50° and 60°, days that occur in some seasons as early as the last part of February, a few tremulous chirps, given as if the frogs were not fully aroused from their winter torpor, come from the sunny, southerly slopes of wooded hills where the same scattered voices presumably were last heard in the autumn. In these warm nooks, protected from the north and east winds, snow and ice disappear first. The wet, flattened, and matted leaves soon become dry and crisp, rustling with every breath of wind that stirs them. With the exception of traces of snow, perhaps on the northerly slopes of the Blue Hills, and the overflow of the meadows, the landscape is scarcely changed from what it was in the Indian summer days. The signs of advancing vegetation are hardly perceptible; there are the same browns and neutral tints, softened by the haze of the south wind, and a like stillness in the wood giving distinctness to any sound. Although *Pickeringii* may be heard on these days before *sylvatica* has appeared in the swamps and ponds, observations of many seasons note the latter species invariably collected at the water and egg-laying in the localities both frequent, in advance of the former. As *sylvatica* gives a note less liable to attract attention, the awakening of those individuals hibernating on land among the dead leaves is not so promptly known as in the case of *Pickeringii*. With both species the time of appearance varies with the temperature of the season.

In 1880 *Pickeringii* was first heard here February 26, the temperature reaching 52° during the day; while in 1883 they were not known to give voice till April 6, when the temperature rose to 58°. In the year included from March 1879 to March 1880 they were heard in Milton in each month of the year, excepting July and January; but this was exceptional, owing to the unusual temperature of days in December and February when the mercury ranged from 40° to 64°. I have no record of the frogs piping first in spring at a temperature below 50°; once called to the surface, however, they give voice at a much lower degree, and, after collecting at the water I have twice heard them, together with *sylvatica*, the wood frog, continue giving voice for a while after the mercury had fallen to 30°. (Mr. Allen, in his notes on *H. Pickeringii*, Proc. Boston Society Natural History, vol. XII, p. 192, notes a similar occurrence at 31°.) Each occasion has followed a sunny day. In one instance the temperature of the air during the day reached 48°; soon after the sun went down it fell to 38°, while the water about the edge of the pond, where the frogs were numerous, was 50–52°. As the air grew chill, light wreaths of vapor arose from the water and were wafted over its surface, almost obscuring shore objects for a few feet above the pond's level. Beneath this veil of mist the piping was at first vigorous, but the water growing colder the vapor gradually cleared; at the same time the "peeps" were fewer and sounded slow and hoarse, as if given with a shiver, till at length the mercury falling below 30° the two or three frogs which appeared to have continued piping, in a spirit of rivalry as to which could endure the greatest degree of cold, were chilled to silence. Morning found a thin ice about the pond and thick hoar frost on the ground.

In average seasons a few frogs may be heard about the 20th of March, but they are not in full voice here much before the first week in April, about which date they collect in great numbers for egg-laying in the shallow overflow of swamps, meadows, and ponds, the males appearing in advance, and, as far as my observation goes, in excess always of the females; but even then their concerts are liable to be interrupted by brief periods of snow and freezing weather when they disappear till the temperature changes again. The advent of an east wind, to the sweep of which they are exposed, disturbs their piping, while the same and even lower temperature with the wind in any other quarter is endured with apparent indifference.

While giving voice the frogs are not moving about in the water, but are partially or wholly out of it, seated along the shallow edge amid dead leaves and grasses or clinging by their sticking disks to the tawny, half-submerged weeds, small bushes, or reeds, where the eye often fails to separate the frog from its surroundings, so perfect is the adaptation of color and form; each curve of body and limb finding counterpart in bent grasses, dead herbage, and leaves. The frogs will be found of various shades of brown and capable of changes within the limitations of that color; they do not, however, trust to the security of this color protection with the stolid indifference of *Hyla versicolor*, the common tree toad. The male frogs are a little smaller than the females of the same age and often darker in tint. As is known, the latter sex has no external vocal sac and gives no note that I am aware. The vocal sac of the male is largely developed in spring; it is of a greenish grey color and lies in loose folds outside the muscles of the throat. Inside the mouth are two slits or orifices, opening into the sac, one on each side near the angle of the jaws. When the frog is about to give voice the whole body is inflated, followed by that of the vocal sac which rounds out into a bubble and does not collapse with each "peep"; the degree of inflation evidently governs the volume of sound. About sunset I have frequently been aided in discovering the frogs by the level rays of the sun striking along the edge of pond or meadow and reflecting from this moist, inflated vocal sac with a glittering light.

Unless the day is overcast, or a warm rain is falling, little is heard from the frogs till about four o' clock in the afternoon when their concerts begin, to be continued in mild nights till morning. Considering the size, the volume of sound possible from one frog is surprising. As you approach a locality where they are in full voice the air seems to grow gradually dense with this ear-deafening, all-pervading sound; occasionally the voices fall into a regular measure of time, but the effect is usually a medley of shrill sounds, a few voices audible above the others by reason of some peculiarity in key, or lack of smoothness in utterance. The piping of each individual is long continued; the interval between these musical efforts appears to depend on the mood of the musician. One does not note the pause of individual voices in the general effect, but, however loud and earnest the piping may be, the introduction of any unusual sound or appearance, even the low quick flight of a bird over the water, is almost sure to give alarm and still them for a while; the frogs along the edge of the shore commonly settling away out of sight for safety among the dead leaves under water, while those having a position on the low bushes or reeds merely cling more closely, flattening the body against the object on which they are resting. The interval of silence is brief; soon a frog rises and gives a shrill "peep," which is immediately answered by dozens of voices. The sounds may appear to come from about your feet, but for the reasons given, the chances are against seeing the frogs till some movement in the water as they rise from their hiding places, arrests the eye, which on perceiving one usually discovers more.

Among the enemies that prey on *Pickeringii* none are more destructive while they are collected at the water than *R. halecina*, the shad frog; both species congregating for egg-laying in the same localities. On one occasion numbers of both frogs had assembled in a small, shallow pool; the peeping frogs were in commotion, swimming about and by turns climbing any available grass or weed stalk to avoid the near approach of *halecina*. Suddenly a gust of wind swept a shower of dead leaves that had remained on the tree all winter, from an oak standing near, and scattered them over the water. No sooner were these graceful rafts afloat than *Pickeringii* appropriated them as points of safety, nearly all of them becoming freighted with a little frog. Hither and thither with the eddying breeze they sailed while *halecina* swam under and about them, the curled and upturned edges of the leaves concealing the little frogs from sight.

Where *Pickeringii* is numerous, a handful of dead grasses and leaves taken at random from the shallow water along the shore will usually be found to contain a few eggs attached singly here and there. Mr. F. W. Putnam, in the Proc. of Boston Society Natural History, vol. IX, p. 229, has already described them as follows: "These eggs were not in a mass or in a string, as is the case with our other frogs and toads, but were isolated, being attached to the plants some distance apart. The tadpoles were hatched in about twelve days, and were very long, coming from the eggs with a more marked tadpole form than is the case with our other species of frogs and toads." To this description I would add that of the color of the egg, which is at first deep brown on the upper surface and cream colored beneath, but in the process of development changes to drab; and the tadpole escapes from the outer membranous shell of a pale yellow color with dots of deep brown on the sides of head and body, and measures about 5 mm. in length (pl. 28, fig 1). The eggs are so small that they might easily pass for scattered seeds of the submerged weeds to which they cling tenaciously by means of the viscid substance surrounding them.

The length of time occupied in the development of the egg varies according to circumstances; in the early part of the season they ordinarily hatch, as Mr. Putnam has observed, in twelve days; as the weather grows warmer I have known it accomplished in seven. Instances might be cited, not only showing that the length of time varies according to the temperature of early spring, but also that eggs laid at the same date may vary somewhat, owing to some difference in the temperature of the water where they are laid. As the season advances and the weather becomes warmer the eggs of all our frogs and toads develop more rapidly; in the summer months I have found but a trifling difference in time.

The tadpole escapes from the outer membranous shell with eyes and mouth in a rudimentary state: the external gills are often more advanced in development than is usual with the other species of frogs and toads found here; the nostril pits are conspicuous and the holders, one each side below and back of the mouth, are prominent. The first stage (Dugès) is passed and the second entered on during the first week; that is, the external gills are developed and resorbed and the tadpole assumes the proportions it afterwards retains. The gills on the right side disappear first; with the resorption of those on the left side, and junction of the thin membrane which has gradually grown downward to the trunk, the branchial cavity and lateral spiraculum are formed. During the first week the mouth is developed so that the deep-brown, horny fringe of teeth at the edge of the lip and folds is defined, and the eyes so that they have some sense of sight; the latter are prominent, set widely apart, and relatively large. The head and body are short and broad; their united length is contained about twice in that of the tail. As soon as the external gills are resorbed the tadpoles leave the objects to which they cling by means of the holders, and may be found darting in and out among the dead grasses and herbage along the shallow water. By the tenth day the holders have disappeared. Like the tadpoles of *Hyla versicolor*, which they so much resemble at this stage, they are extremely quick in movement and, where there is space, do not herd together. Search for food (and for this they mouth against whatever comes in their way, taking animal food eagerly, devouring one another as soon as dead, or even while alive if too disabled to move), escape from enemies, with periods for rest and sleep, appear to be the events of their existence during the larval changes. As soon as the arms are thrown out the tadpoles are in haste to leave the water, climbing the plants, sedge, or graceful panic and manna grasses (*Panicum dichotomum*, *Glyceria pallida*) that often choke the shallow water; the holding power of the dilated tips of fingers and toes enabling them to cling to an object regardless of position. I have found them a yard or more from the water before the tail was much resorbed, but for safety they would immediately turn to that element. Tadpoles of *Pickeringii* ordinarily pass about eight weeks in the larval condition. The same disastrous results that sometimes overtake the larvae of *sylvatica* and *halecina* are shared by *Pickeringii* in the evaporation of the shallow water of swamps, bogs, meadows, and small ponds created by the spring rains and melted snow and ice. They collect in the pools left where the water has receded, shut in with water enemies, growing thin and maimed, till the water here also evaporates and all perish. It sometimes happens that the oldest tadpoles of *sylvatica* and *Pickeringii* are hurried through their transformation under these conditions before it is accomplished elsewhere, but both tadpoles and young frogs are pale in color and small in size; the former lacking almost wholly the metallic coloring usually conspicuously brilliant. All trace of the tadpoles, left to perish, is soon gone. This wholesale destruction of life in one direction is Nature's bounty in another. On the soft mud one finds a net-work of footprints made by various birds, and now and then tracks of a skunk which, in his nightly foraging, evidently found a feast here. Conspicuous among the birds' tracks are those of the crow, whose gait finds expression in the inward-turning impress of the toes; and occasionally, sunk in the soft mud, are the large, well-defined tracks of the heron. It is not rare to find the footprints and borings of the woodcock here, the toe-marks almost at right angles, and the soft earth punctured by the probing of the bird's long bill for worms. Those tadpoles of *Pickeringii* escaping this fate are constantly being lessened in number by their enemies, the newts, water beetles, and the larvae of the beetles and dragon flies. On two occasions I have seen a spider (*Dolomedes sexpunctatus*) run along the surface of the water, suddenly dive, seize, and drag out on land a full-grown tadpole of this species; the spider coming out dry, evidently as much at home in as out of the water.

The young frogs on leaving the water may be found for a short time on and under the growth of herbage that has sprung up about it; they are exquisite in form and agile in movement. The quiver of a small leaf and dip of a slender grass blade, as the frog leaves the one to spring to the other, frequently betray their presence, but their object is evidently to seek cool, damp, shaded places. When numerous, they sound on the dry, dead leaves as they spring out of your way, like the patter of the first rain drops in a summer shower.

By the first week of June, and in some seasons by the third week of May, the period of egg-laying is over, and all the adult frogs have become silent and left the water, the concerts gradually diminishing in volume as the musicians grow fewer in numbers. I have never heard them give voice in July, and have rarely found the adults in that month. With the muggy days of August piping is resumed, but it is not general as in spring or sustained with such volume and energy; the "peeps" frequently mingle almost unnoticed with the chirp and murmur of birds and insects. At this season I have found the frogs, not only on the ground, and on the ferns, and bushes in the wood, but in the vegetable garden, and on the lilac bushes, apple, pear, and elm trees, evidently in search of insects.

One day I happened on one of these little frogs on the grey limb of an apple tree; he was motionless, with the exception of the constantly palpitating throat; his hands and feet were compactly folded under him, only their outer edges coming in contact with the surface on which he rested; the same sensitiveness in regard to the disks is shown with the peeping frogs as may be observed with the tree toad; the eyes were depressed, pupil contracted, and the frog seemed to me to be asleep, till suddenly his attention was arrested; the eyes were raised, the pupil dilated, the narrowed iris glowed; the hands and feet sought the limb, the toes of the feet twitched nervously, and with startling quickness the sure leap was made; the gauzy wings of some insect, a mosquito I thought, protruding from between the closed lips explained the movement. Although following the direction of the frog's earnest gaze I could not detect the object which attracted him. There was a pause of a minute or more before the insect was swallowed. Then the frog tucked hands and feet under him and to all appearance became wholly oblivious to everything about him. In common with the other frogs and toads found here, the tongue, as has been often described, is free behind and fastened down by the front edge to the inner rim of the under jaw; it is heart-shaped and capable of some distension. When food is taken the free edge is thrown forward and drawn back so instantaneously, that the eye can seldom follow the movement, or perceive what has been captured.

I have not often heard the piping repeated after dark in the autumn, the nights being generally too cool. The frogs are most active and musical at this season, on those muggy days when the south wind drives low-flying clouds across the sky; they are evidently in sympathy with this peculiar warmth and moisture. Above the rush of the wind, as it sweeps through the wood, stripping the dead leaves from the trees, whirling and scattering them before it like a flock of birds, the shrill voice of this little frog makes itself heard. Guided by their piping I have several times found them clinging to the brown oak leaves fallen from the trees above, and lodged in the top branches of the blueberry and alder bushes growing beneath them: the frogs, accidently or with intention, choosing a position where, if silent, detection would be almost impossible. As the awakening of *Pickeringii* accompanies the first bland days that come with the higher circling sun of approaching spring, so their subdued notes, in harmony with the year grown faded and silent, are associated with the mild days that linger latest in the autumn.

The chances of finding the frogs in a torpid state are few, both on account of color and size. Whenever I have seen them among the fallen leaves, it has been the result of accident. I once happened on one in winter under the leaves collected in the deep rut of a cart path in the wood; the frog was without motion and apparently dead, but the warmth of my hand soon affected him; the nostrils showed faintly at first the action of air passing through them, the inferior eyelid began to lower, and the frog soon developed an activity that threatened my losing him and seriously interfered with further observation. On reaching home and exposing him to the warmth within doors he soon gave voice with energy. The frogs kept in the house in a torpid condition during the winter, whenever exposed to a temperature of 50° would soon come out from under the moss, where they secreted themselves, and pipe, evidently under the impression that spring had come. The young frogs do not reach their growth the year of their birth, although the females lay eggs the following spring.

Explanation of Plate XXVIII.

Fig. 1. *Hyla Pickeringii*, tadpole, first day, natural size 5 mm. long.
Fig. 2. *Mouth of tadpole*, enlarged.
Fig. 3. *Single tooth of fringed fold*, much enlarged.
Fig. 4. *Part of fringed fold*, enlarged.
Fig. 5. *Adult female.*
Fig. 6. *Frogs* showing vocal sac inflated and collapsed.
Fig. 7. *Adult male.*
The figures in water show the eggs and tadpoles from time of hatching to the young frog.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XII. Palaeodictyoptera: or the Affinities and Classification of Paleozoic Hexapoda.

By Samuel H. Scudder.

Read February 18, 1885.

Excepting the cockroaches, which form so large a proportion of carboniferous insects, most of the known paleozoic hexapods have long been referred to Neuroptera. But the opinion has been gradually gaining ground that (1) the wide divergence of some of them from post-paleozoic as well as from existing forms, and (2) the occasional unexpected proofs of the combination in single individuals of characters now only known to exist separately in insects of distinct ordinal divisions, *i.e.*, the appearance of broadly synthetic or generalized types, required some modification of our earlier notions. The discovery of Eugereon and the discussion of its structural peculiarities by Dohrn, Hagen, Gerstaecker, Snellen van Vollenhoven, Packard, Brauer, Goldenberg, etc., did more than any thing else to suggest and enforce this opinion.

Dohrn himself in his very earliest paper went so far as to propose to place Eugereon in an ordinal group apart under the name of Dictyoptera, and in the following year to add to the same order the group of insects then known under the name of Dictyoneura. Ten years later, in changing this ordinal name to Palaeodictyoptera, on account of previous employment of Dohrn's term, Goldenberg also included in it the types described by Dana as Miamia and Hemeristia, and Beneden's Omalia; Brongniart has of late years employed it in much the same sense, his only really distinctive addition being that of Geinitz's Ephemerites[1].

The recent startling discovery by Brongniart of insects plainly related in no very distant way to modern Phasmida,—a highly specialized and unique group of Orthoptera,—but yet bearing wings whose venation compels us to connect them directly with the synchronous type of Dictyoneura,[2] and which had heretofore been supposed either neuropterous or to belong to an archaic type some of whose members showed distinct hemipterous characteristics:—

[1] In his latest writings Brongniart, influenced no doubt by the striking combination of neuropterous and orthopterous characters which he discovered in Protophasma and Titanophasma, has endeavored to supplant this term by Névrorthoptères. Three distinct objections can be made to this: 1. The group already has a good name which has been previously accepted by Brongniart, and which the recognized laws of nomenclature will not allow us to set aside; 2, as a distinctive term his fails to cover the synthetic characters of the entire group (cf. Eugereon); 3, the accepted language of nomenclature is Latin and not French.

[2] See Proc. Amer. Acad., XX, 167–173.

this discovery following close upon my demonstration that all paleozoic cockroaches belonged to a type distinct from and taxonomically equivalent to existing Blattariae, lends countenance to a new attempt to discuss the relationship of all paleozoic hexapods to each other and to later types. The time has plainly come for a revision of our general knowledge in the light of special discoveries.

Our acquaintance with paleozoic hexapods is mainly based upon the structure of the wings, and this is greatly simplified by the fact that, as has been previously noted, differentiation in the structure of the front and hind wings of insects had not in paleozoic times obscured the neural framework of the front wings. It is nevertheless true that the great advances in our knowledge of relationships among paleozoic insects have *not* come from a study of the wings, but from the happy and rare discoveries of other parts of the bodily structure, as in Eugereon and Protophasma. This would be supposed to render any attempt to reduce the entire series to systematic order somewhat hazardous, were it not that, as will appear later, the great body of forms now known can be grouped, by their wing structure, into a few distinct types, whose relation *inter se* is such as to warrant a belief that they must have been structurally related in the rest of their organization; and that, among the forms so related, one or another has generally preserved such fragments of the body as enable one to speak with some degree of confidence; at the same time it will have to be admitted that while we are dealing with imperfect remains, any deductions which may be drawn from inferred structure is valuable only as it is cumulative.

Brongniart in his latest papers, while, as stated above in a note, unnecessarily and undesirably dropping the name Palaeodictyoptera,—a name historically connected with the greatest advances in our knowledge of the relationship of paleozoic insects,—has also extended its scope, so as to include also all the forms he (and others) had previously placed under Neuroptera and Orthoptera, but, impliedly, leaving the species of Fulgorina still under Hemiptera. There is no reason for this exclusion, and it is probable that it was not intended.

Leaving aside, for a moment, the question of the existence of paleozoic Coleoptera, we submit that the same reasons which would justify the use of the term Palaeodictyoptera for Eugereon alone, as was done in the first instance by Dohrn (for its predecessor Dictyoptera), compel us to include in it the entire series of paleozoic hexapods. It is a name too which is peculiarly appropriate to the insects of the paleozoic epoch as a whole, with their undifferentiated wings. It is as applicable to the ancient ephemerids as to the phasmids or cockroaches, and any definition of it grounded on known characteristics must be based almost wholly upon the structure of the wings, from which the name is derived; this structure is, collectively, so simple, the similarity between representatives of groups whose descendants are afterwards ordinally distinct so striking, that we may be justified in claiming the probability of the homogeneity of other parts of their structure. At all events the known facts of the structure of paleozoic insects, apart from the historic development of the hexapod type in subsequent epochs, would warrant no ordinal separation between them. In saying this I do not overlook the fact that Eugereon was probably a sucking, and Protophasma a biting, insect, for a physiological distinction is of itself of no value whatsoever; it is the underlying structure only that should be considered; and we have no fact beyond the *subsequent* development of biting types into groups ordinally distinct from sucking types (a fact paralleled in wing structure), to show that from the structure of the mouth parts Eugereon should be ordinally separated from Protophasma.

Whether the paleozoic relics which have been referred to Coleoptera should also be grouped with the Palaeodictyoptera is another question. That coleopteriform insects then existed is I think probable, both from the traces which are reasonably referred to borings similar to those made by existing types, and by the present structural relationship of Coleoptera to types whose predecessors are most plainly recognized among paleozoic forms, *i.e.* other Heterometabola. Troxites—the single relic from the paleozoic referred to Coleoptera—is an obscure object, and may, as Brongniart has suggested, be the fruit of a plant. It seems to me most probable, all things considered, that Coleoptera sprang from such Palaeodictyoptera as were wood-borers throughout life, and which in paleozoic times had no greater differentiation of structure between the front and hind wings than exist in other Palaeodictyoptera. Such differentiation would be likely to arise from the preservation of favored races with such a habit; while the inherent probability that *all* the heterometabolous types had their already diverging stems in paleozoic times, coupled with the entire absence from these rocks of any shards of beetles, which in later rocks are the most readily and frequently preserved of all insect remains, renders the supposition the more acceptable.

If then, Troxites be a fruit, and the above hypothesis account for what are apparently beetle borings in the older deposits, we have left one insect only, Phthanocoris, claimed to come from paleozoic rocks, which shows any considerable sign of such differentiation in structure as led to the existing distinction between the front and hind wings of heterometabolous types, as we now know them.

Another reason for the claim here urged, viz., that all paleozoic insects should be grouped in one order, Palaeodictyoptera, is to be found in the fact that whenever any of the special groups which it includes, whose distinct affinities to special modern types are easily recognized, are compared with these types, they are found to possess characters which distinguish them as a whole from them. My meaning here will be clear by reference to my paper on paleozoic cockroaches; these insects, though plainly cockroaches or the ancestors of existing cockroaches, are nevertheless structurally distinct from the latter to such a degree that it was necessary to recognize them as a separate group, Palaeoblattariae, taxonomically equivalent to the entire modern group Blattariae. The passage from one group to the other took place in early mesozoic times.

The above view of Palaeodictyoptera then reduces itself to simply this: that hexapodous insects were not ordinally differentiated until post-paleozoic time. The example we have given above, however, sufficiently indicates the next step we must take, and that is to distinguish between groups which the historic development of insects shows were the precursors of types ordinally distinct. This it is difficult to do on any other basis than that of *family-continuity*. It is comparatively easy to see that the Palaeoblattariae were the probable ancestors of Blattariae, Protophasmida the precursors of Phasmida, Palephemeridae of Ephemeridae, and Hemeristina perhaps of Sialina; but from wing structure alone, Palaeoblattariae (ancient Orthoptera) are as nearly allied to Palaeopterina (ancient Neuroptera) as they are to Protophasmida (other ancient Orthoptera). Our clew is through the minor groups, and by their aid, and almost entirely by their aid, we may distinguish between orthopteroid, neuropteroid, and hemipteroid Palaeodictyoptera.

PALAEODICTYOPTERA.

Body more or less elongate, composed of three well-defined regions, head, thorax, and abdomen; mouth parts as in modern Hexapoda, variously developed; antennae filiform, simple; eyes compound. Thorax three-jointed, subequally developed, each joint bearing a pair of moderately long legs; the meso- and metathoracic wings closely similar, equally membranous, supported by a framework in which six principal stems are developed, the first of which always forms the costal margin; the mediastinal is simple or only provided with superior branches, the scapular and internomedian simple or compound, the externomedian and anal nearly always compound, their branches almost always inferior; generally most branches dichotomize; the membrane is usually more or less reticulate with generally irregular polygonal cells; stout and well-defined cross veins are rare; the costal area is generally scant, the anal area generally ample, often very ample, yet not so much from depth as from distal extension; when at rest the wings appear in all cases to have covered the abdomen as in modern cockroaches, white ants and Sialina; but although there is some indication from their greater breadth that the hind wings were then folded, they were never plaited like a fan as in modern Orthoptera. The abdomen was usually long and slender, composed of nine or ten joints, the last one sometimes furnished with a pair of articulated appendages.

[Orthopteroid Palaeodictyoptera.]

PALAEOBLATTARIAE Scudder.

The points in which the ancient cockroaches differed from existing types has been fully pointed out in a comparatively recent paper,[1] and need not be repeated here. The classification there proposed has been generally accepted and no little addition to our knowledge of ancient types of cockroaches has since been added. A number of undescribed forms are in my hands from American deposits, including several new genera, and will be made the subject of special papers. Recent explorations in Triassic beds of Colorado have thrown new light[2] on the passage of the Palaeoblattariae to later types and it is announced by Brongniart that he has discovered a cockroach in the middle Silurian. The figures he has given, however (La Nature xiii, 116), though unsatisfactory, would lead us to suppose the insect to belong to the neuropteroid Palaeodictyoptera.

PROTOPHASMIDA Brongniart.

A classification of the members of this group having been recently proposed by me[3], and as I intend to refer to them more fully on another occasion in fully describing and

[1] Mem. Bost. Soc. Nat. Hist., III, 23–134.

[2] Amer. Journ. Sc., (3) XXVIII, 199–203.

[3] Proc. Amer. Acad. Acad. Arts. Sc., XX, 167–173. A careless error which crept into this paper may be corrected here. Dict. elongata Gold. was placed in both Breyeria and Goldenbergia! It was at first supposed to belong to Breyeria and was accidently left there after it was discovered that its true place was in Goldenbergia.

illustrating the American forms, it will not be necessary to enlarge upon them here. It may be added, however, that the Devonian Gerephemera falls in this group, and that Brongniart is probably correct in assigning Archaeoptilus Scudd. to the vicinity of Dictyoneura.

Archegogryllus priscus (Pl. 29, figs. 2 ...)

Archegogryllus priscus Scudd., Proc. Bost. Soc. Nat. Hist. XI, 102-103.

In now publishing figures of this fossil, I place it among orthopteroid Palaeoblattariae simply in accordance with my early determination of it, not wishing to speak positively as to the character of so fragmentary and uncertain a specimen. The remains consist of what appears to be a broken leg, and of a fragment of a wing in close contiguity but possibly not at exactly the same level. The wing, as may be seen by the figure, shows only a few parallel veins of varying degrees of stoutness, with one, apparently detached, crossing several at an acute angle; no sign of any margin is seen excepting in the presence above of two or three very distant, delicate, arcuate, oblique veins, apparently of the costal area. The leg is broken into fragments from which an apparent saltatorial femur and a very irregular tibia can be made out, the general course of each straight, but bent at a slight angle with each other. They are somewhat remarkable, for the femur is smooth, has a median flat area bounded by slight ridges, while the tibia is furnished with several prominences of large size; in modern types the prominences when they occur are found only on the femur. There is a slight rounded prominence on the upper surface near the very base of the tibia and another a little beyond the middle; opposite the latter on the upper surface, is a deeply cleft elevation, its hollow corresponding to the elevation on the upper surface; the basal half of the under surface is occupied by a very broad prominence, of nearly equal height throughout, but slightly depressed in the middle and terminating abruptly at either end. The femur is slightly larger than the tibia and more than twice as broad. Length of wing fragment 15 mm., width of same 11.5 mm., length of femur 10 mm., greatest breadth of same 3.1 mm., length of tibia 8.5 mm., breadth of same at base 1.5 mm., at tip 1 mm. More has been uncovered since its first description.

The specimen was obtained by Dr. J. S. Newberry in the lowest coal beds at Tallmadge, Ohio.

[Neuropteroid Palaeodictyoptera.]

Palephemeridae Scudder.

This name has just been proposed by me[1] for the ancient Ephemeridae, in which the lower seems to be formed on the same plan as the upper externomedian stem. The ancient types are distinguishable from their fellows, as the modern are from most of theirs, by the great number of cross veins breaking the interspaces into generally quadrangular cells larger then the fine irregular reticulation of other paleozoic insects. The following insects may be referred here:—

Palephemera antiqua Scudd., Dev. Ins. N. Brunsw. 7, pl. 1, f. 5, 9, 10; Devonian, St. John, New Brunswick.

[1] Earliest winged ins. Amer., Cambridge, 1885, p. 4.

Ephemerites Ruckerti GEINITZ. Jahrb. f. Miner., 1865, 385, pl. 2, f. 1; Lower Dyas. Reitsch, Saxony.

Palingenia Feistmantelii FRITSCH. Beitr. Pal. Oesterr.-Ung. ii, pl. 1, f. 1-6; Carboniferous, Bohemia.

Although one can hardly doubt the position of this insect, the resemblance of the abdominal appendages to those of Dictyoneura Goldenbergi Brongn., as shown in a sketch kindly sent me by Brongniart, is very striking.

HOMOTHETIDAE Scudder.

Though one of the characters upon which this group was originally founded has proved to be fallacious, so as to require an entire revision of the neuration of the single insect upon which it was founded, the name may still be applied to the otherwise unnamed group into which I have since discovered that it must fall, as I have proposed in a recent publication.[1]

In this group, which contains a considerable variety of forms, the mediastinal vein terminates on the costa at very varying distances from the tip, being sometimes very brief (Cheliphlebia), at other times very long (Homothetus), almost invariably sending a considerable number of short, oblique, usually simple veins to the margin. The scapular vein, which has no inferior branches, generally runs parallel to, but at no great distance from, the mediastinal, and after passing its limits, which it generally does to a conspicuous degree, continues the emission of branches to the margin now dropped by the mediastinal; this vein seems invariably to terminate just before the tip of the wing. The externomedian vein is generally the principal branched vein, though there is a curious exception in Didymophleps. It generally begins to branch about or a little before the middle of the wing, and then emits from its main stem at regular intervals from three to six oblique nervules, simple or simply forked, and so longitudinal in course that the area rarely infringes far on the inner margin. The internomedian vein is also conspicuously branched, the area generally occupying the larger part of the lower margin, though the anal area not infrequently reaches nearly to the middle of the wing; its mode of branching is very variable; generally it closely resembles the preceding vein, sometimes to such a degree as to make all the offshoots appear as branches of one vein, at other times only beginning to part from the stem after the latter has taken the oblique course of the externomedian branches, and then having a different obliquity. The anal area is generally though not always narrow, but often reaches far out toward the middle of the wing, and the vein is abundantly branched.

This family is readily distinguished from the Palaeopterina, to which it seems most nearly allied, by the course of the mediastinal vein, which terminates on the costa and not on the scapular vein. The externomedian area is also almost always more extensive, and its veins less longitudinal, by which the internomedian area extends to the end of the lower margin of the wing. It would be hard to say to what modern family of Neuroptera it was most nearly allied, as its scapular vein is completely simple, but the general aspect of the neuration leads one to consider it more nearly allied to the neuropterous than the pseudo-neuropterous groups.

[1] Earliest winged ins. Amer. p. 5, 6.

The following are some of the forms falling here, arranged, as far as may be, in their natural sequence.

Acridites priscus

Acridites priscus ANDREE, Neues Jahrb. Miner., 1864, 163-164, pl. 1, fig. 1.

This species is remarkable for the great length of the mediastinal vein and its uniform distance from the margin, which suggest that it may be a hind wing. Andree referred it to Orthoptera. It comes from the Bohemian coal measures at Stradonitz

A fragment of a wing, figured here on pl. 29, fig. 9, seems to come in this vicinity. It is remarkable for the excessive length of the mediastinal vein, the longitudinal obliquity of the branches of the same, and the confinement of the branches of the scapular vein to one or two brief nervules at the very tip of the wing. The externomedian branches seem to be almost similarly confined, while the internomedian branches are crowded, nearly straight, and simple or apically forked. It also has the appearance of a hind wing. It comes from the carboniferous beds of Mazon Creek, Ill., and was received from Mr. R. D. Lacoe, in whose collection it bears the number 2055

Eucaenus (εὐ, καινός) gen. nov.

Stout bodied, the thoracic segments twice as broad as long, the meso- and metathorax very large; the abdomen ovate, the final segments with a median keel; front wings very regular, oblong obovate, the costal border uniformly arcuate, the mediastinal vein straight, terminating before the apical third of the wing, with numerous straight, simple and regular branches; scapular vein terminating midway between the end of the mediastinal vein and the tip of the wing, with similar branches; externomedian vein very important with rather distant branches.

Eucaenus ovalis sp. nov. Pl. 29, fig. 1

The fore-wings are very regularly rounded, a little more than three times as long as broad, the tip situated rather below the middle, only a little above the termination of the middle externomedian branch; externomedian branches about five in number, taking a course about parallel to the apical third of the costal margin, very distant compared to the mediastinal branches, always forked, sometimes doubly; anal veins more oblique, numerous and parallel. The prothorax has a slight median ridge, and the flat fore femora are minutely, distantly and rather coarsely granulate. Length of body (excepting the missing head) 22 mm., breadth of abdomen 7 mm., length of front wings 22 mm., their probable breadth 7 mm.

A single specimen is known from Mazon Creek and bears, in the collection of Mr. R. D. Lacoe, the number 2049.

Gerapompus (γῆρα, πομπός) gen. nov.

Body slender, elongated, the meso- and metathorax tolerably stout, but the prothorax at last as long as broad. Front wings obovate, the costal margin slightly less arcuate in the middle than at either extremity, the mediastinal vein subparallel to the costa and terminating near the apical third of the wing, with rather distant simple branches; scapular vein terminating near the tip, with longer and usually forked but otherwise similar branches. Externomedian vein very important with numerous, very long, generally forked, curving branches, subparallel to the outer half of the costal border.

Gerapompus blattinoides sp. nov. Pl. 29, fig. 1.

The general aspect of the closed wings is that of a cockroach. The prothorax is suborbiform, not unlike that of some Carabidae, with a blunt subcentral boss; the parts in front are obscure. The hind leg is rather long, the femur much stouter than the shorter tibia, the tarsi obscure but nearly as long as the tibia. Wings slightly produced at the apex, but well rounded, less than three times as long as broad. Scapular vein first forking some way beyond the middle of the wing, at or beyond the last fork of the mediastinal vein, and then at once curving downward to approach the margin less rapidly. Length of prothorax 3.5 mm., hind tibia 4 mm., breadth of hind femur 1.5 mm., length of front wing 20 mm., breadth of same 7.5 mm.

The carboniferous beds of Mazon Creek; discovered by Mr. F. T. Bliss.

Gerapompus extensus sp. nov. Pl. 29, figs. 5, 8.

The prothorax is quadrate, the mesothorax of the same width in front as the prothorax, but widening posteriorly; the head apparently a little smaller than the prothorax. Fore wings tapering apically but rounded at the tip, less than three times the length of their median width, the costal margin less arcuate than in the preceding species. Scapular vein nearly straight, first branched near the middle of the wing, some distance before the final forking of the mediastinal vein, and unaccompanied by any change in the direction of the stem. Hind wings, very similar to the front wings in size and shape but with the branches of the externomedian vein much more transversely oblique and curving in the opposite sense, their open side being toward the tip of the wing. Length of prothorax 3 mm., breadth of same 3 mm., length of front wings 30 mm., median width of same 11 mm.

Mazon Creek, Mr. R. D. Lacoe, No. 2019.

Anthracothremma (ἄνθραξ, θρέμμα) gen. nov.

Body stout, apparently depressed, the thoracic segments several times broader than long, tapering anteriorly to a subtriangular head and more gradually behind along the almost parallel-sided abdomen, broader at tip than the head. Wings elongated, with nearly straight costal margin, extending far beyond the abdomen; the mediastinal vein extends over about two-thirds of the wing; the scapular vein rather strongly arcuate, and reaching very near to the tip; the externomedian vein closely parallel to the latter, commencing to branch before the middle of the wing and emitting many long, parallel, simple or simply forked, straight or gently curving, longitudinally oblique branches; internomedian branches scant.

Anthracothremma robusta, sp. nov. Pl. 30, fig. 1, 5, 6

The surface of the body in the specimen illustrated in fig. 6 is not well enough preserved to show much texture, but the head appears to have a median suture and to taper rapidly to a rounded front in advance of the lateral eyes. The prothorax, although very short and transverse, tapers rapidly in front; the mesothorax is a little larger and longer than the metathorax, which does not exceed the abdominal segments in length. The front wings are three and a quarter times longer than broad, with the costa very straight excepting at the extremities; the stiffness of the wing, however, is relieved by the arcuation of the principal veins; the branches of the mediastinal vein are simple, oblique, a little curved, not crowded; those of the scapular vein are few in number, lie wholly beyond the mediastinal and are rather vague; those of the externomedian vein are nearly straight, on one wing about half of them forked at varying distances along the stem, on the other wing in the single specimen at hand most of them simple, and one transferred from the main stem to a forking branch; they are equidistant and not closely crowded. Legs stout and flattened. Length of body 30 mm., of head 3.25 mm., of prothorax 1.5 mm., of entire thorax 6.25 mm., of abdomen 19 mm., breadth of head 4 mm., of thorax 10 mm., of last segment of abdomen 5 mm., length of front wings 28 mm., breadth of same 8.65 mm.

Mazon Creek, Ill. Carboniferous. Collection of Mr. R. D. Lacoe, No. 2018.

Another specimen (figs. 1, 5) is better preserved in some parts, showing the texture of the body to have been uniformly and delicately granulose. The borders of the head are imperfect so that the drawing may here be incorrect. The tip of one of the wings is better preserved so that the form can be better determined. Nothing additional can be gained from the neuration. It comes from the same locality and bears in Mr. Lacoe's collection the number 2052.

Genopteryx (γένος πτέρυξ) gen. nov.

Wings obovate, with more or less arched costa, and somewhat produced apex; mediastinal vein of variable length, the scapular extending to or nearly to the tip, connected to the veins on either side of it by transverse or oblique cross-veins; externomedian vein very important, commencing to branch considerably before the middle of the wing and by several longitudinally oblique mostly forked veins, closely connected by feebler cross veins, feeding the apex of the wing; internomedian vein also important with several similar veins, the outermost of which runs in close proximity to the basal externomedian branch from its very origin, so that at first sight both externomedian and internomedian branches appear to spring from a common vein.

Genopteryx constricta, sp. nov. Pl. 29, fig. 11.

A single broken wing is preserved with part of another, probably of the same side. It conforms best to the generic characters laid down above in the similar appearance of the externomedian and internomedian branches, which are all less longitudinally disposed than in G. lithanthraca. Another marked distinction from that species is in the comparative narrowness of the area of the wing above the scapular vein, due partly to the less strongly convex costal margin, and in the much greater length of the mediastinal vein, which in G. lithanthraca scarcely extends beyond the middle third of the wing, while here it does not stop much short of the tip. Probable length of wing 30 mm., its breadth, 8.25 mm.

Carboniferous beds of Mazon Creek (Mr. R. D. Lacoe No. 2046).

Genopteryx lithanthraca.

Gryllacris lithanthraca GOLD., Palaeontogr., IV, 24-27, pl. 4, figs. 1, 2.

Carboniferous deposits of Fischback and Rushütte near Saarbrücken, Germany.

Cheliphlebia (χηλή, φλέβιον) gen. nov.

A large coarse-winged group, with tolerably slender form, indicated by the position of the wings in repose and marks on the stone too vague to be well represented. The wings are elongated with sub-parallel borders, have a scarcely arcuate costal margin and variable tip, and cross veins, unless exceedingly feeble, entirely absent. The mediastinal vein is short, terminating before the middle of the wing. The scapular vein being distant from the margin, though tolerably straight and supplying many oblique branches to the same, reminds one of the species last mentioned. The externomedian veins are few, distant, simple or compound, and terminate mostly on the apical margin; while the internomedian vein extends far towards the extremity of the lower margin parallel to the externomedian branches, and feeds all that margin with transversely oblique, curving branches. This feature, most conspicuous in the first of the species, has suggested the generic name.

Cheliphlebia carbonaria, sp. nov. Pl. 30, fig. 8.

The wing is about three times as long as broad, uniform in breadth over most of its extent, with a very broadly rounded tip. The middle third of the lower margin is almost perfectly straight, giving a stiff appearance to the wing, which seems to be largest beyond the middle; the veins are very pronounced. The mediastinal branches are very different from those of the rest of the wing, being feeble, crowded and arborescent. The internomedian branches, which are distant, are pretty strongly curved, their convexities toward the tip of the wing, and especially curved when, toward the margin, they fork in a claw-like fashion. The anal veins are few in number and more longitudinal than the internomedian branches. Length of wing, probably, 38 mm., breadth 13 mm.

Carboniferous nodules of Mazon Creek, Ill. (Mr. R. D. Lacoe. No. 2034.)

Cheliphlebia elongata, sp. nov. Pl. 29, fig. 7.

The wing is probably about three and a half times longer than broad, broadest in the middle, and beyond that regularly tapering to a prolonged and probably somewhat pointed tip; the veins are obscure. The mediastinal branches seem to be few, distant and simple. The externomedian branches differ considerably on the two front wings, being of the usual type on one side, but more or less arborescent on the other, the subordinate branches forking more than the more important ones. The internomedian branches, which are not distant, are rather gently curved, with their convexities away from the apex of the wing.

Length of fragment of wing 25 mm., probable complete length 28 mm., breadth 7.75 mm.
Carboniferous beds of Mazon Creek, Ill. (Mr. L. M. Umbach.)

The specimen figured on pl. 30, fig. 7, also belongs to this family, but too little of the neuration is preserved to enable one to speak with any confidence of its exact position. It would seem probable that it should fall here. The insect is exposed on a side view and the wings overlap so as to confuse the neuration at the costal border, but the mediastinal and scapular veins are plainly simple and the former ends on the costa and has few or no branches. The body was elongated and the wings probably about 35 mm. long. It comes from Mazon Creek, Illinois, and bears the number 2018 in the collection of Mr. R. D. Lacoe.

Genentomum (γένος, ἔντομον) gen. nov.

The wings in this group are large and elongated with coarse neuration and abundant, somewhat feeble cross veins. The front is more ovate than the hind wing, the costal margin being more arched, the tip apparently more pointed and the anal area more excised. The mediastinal vein is long, at least two-thirds the length of the wing, and sends abundant though not crowded branches to the costal margin. The scapular vein lies very close to it and emits no branches until beyond it, when it sends off a few more oblique ones and itself extends to the tip. The externomedian vein is separated by an unusual interval from the scapular and emits several stout forked branches, which cover the apical and the extreme outer part of the inferior border. The internomedian vein is forked once or twice only in the front wing, the branches appearing similar to those of the preceding vein; while in the hind wing it bears many shorter and much more oblique inferior branches.

Genentomum validum, sp. nov. Pl. 30, figs. 2, 3.

The only parts preserved in the single specimen known are the greater portions of two wings, a front and a hind wing, widely separated from each other but in the same nodule. In the front wing the greater part of the costal margin, including all of the mediastinal vein and its branches, is destroyed, unless as is probable the first vein shown is the extremity of this vein; in the hind wing the branches of this vein are oblique, increasingly longitudinal away from the base, and often forked and sinuous. In the front wing the externomedian vein is separated from the scapular by a space about equal to the interspaces between its branches before they fork, and is connected with it by distant transverse cross veins, breaking the interspace up into subquadrate cells; in the hind wing, the course of the vein is not so straight, it is rather more widely separated from the scapular vein and, besides the transverse veins, the interspace is traversed by a supplementary, longitudinal, binding vein in the middle of the wing nearly a fourth the length of the latter; the branches of the externomedian vein are more frequently and extensively forked in the front than in the hind wing but do not differ much. The internomedian vein is soon forked in the front wings and both branches again dichotomize to a considerable extent, while in the hind wing half a dozen simple arcuate branches, their concavities toward the apex of the wing, part from the under side of the single stem. The anal area is broader and the veins more numerous in the hind than in the front wings, but in both they are tolerably simple and take the course of the externomedian branches; near the base they are separated by a broad space from the internomedian branches, a space which is occupied in both wings by a number of longitudinal arcuate wrinkles or independent cross veins, difficult fully to understand. The front wing is broadest about the middle; the hind wing, notwithstanding its basal expansion, in the middle of the outer half.

It may be added that on the same stone (reversed of course on its counterpart) the scapular vein of the front wing is depressed, and the externomedian and internomedian veins with all their branches raised; while in the hind wing, the mediastinal vein, the externomedian vein and its branches, and the branches (only) of the internomedian vein are depressed, while the scapular, the supplementary binding vein and the main internomedian are elevated; showing that on this stone (the one drawn) we see the two wings of one side, one of them upside down. Length of wings 45 mm., breadth 14 mm.

Carboniferous deposits of Mazon Creek. From the collection of Mr. R. D. Lacoe, No. 2047.

Didymophleps (δίδυμος, φλέψ) gen. nov.

This is one of the most anomalous genera of this family, all the veins and branches above the internomedian being longitudinal and nearly parallel to each other and the straight costal margin; the externomedian vein is twice forked not far from the base of the wing, and all the branches run in the same general direction; so does the internomedian vein, which is exceptionally developed, and emits a considerable number of rather distant, parallel, oblique, rarely forked, nearly straight branches.

Didymophleps contusa. Pl. 29, fig. 6.

Termes contusus Scudd., Proc. Bost. Soc. Nat. Hist., XIX, 300-301.

The body is crushed past all recognition, and fragments of legs lying between the wings only show that they were slender. The wings, also, are only partially preserved, their bases being destroyed with the crushing of the body and their tips by extending beyond the edge of the nodule in which they are enclosed; more than half of each wing remains, however, comprising some of the more important parts. All the veins from the marginal to the internomedian inclusive, as far as they are traceable on the stone, are nearly straight and parallel: the upper three are also simple, and the scapular area is considerably and uniformly depressed; the externomedian vein is forked near the base of the wing and the space included between the forks, as well as the externomedian area, is traversed by feeble, inequidistant, straight or oblique cross veins. The internomedian vein traverses the middle of the wing, or runs scarcely above it, and emits from its lower border a large number of oblique veins, which run, often with a slightly irregular course, to the margin of the wing: in the fragment there are eight such veins on one wing and six on the other and more imperfect wing, in both cases about equidistant, but more regular and straighter on the left than on the right wing, in both also one of the secondary veins, and one only, arising shortly before the middle of the wing, is forked — on the left side close to its origin, on the right side near the middle of its course. Both borders are perfectly preserved on the right wing, showing it to be 10 mm. broad; the length of the larger fragment is 20 mm., and the probable length of the wing about 35 mm.

Coal measures of Vermilion Co. Illinois, obtained and sent to me by Mr. Wm. Gurley.

Homothetus Scudder.

The characters of this genus having been misapprehended by me in my detailed paper on the "Devonian Insects of New Brunswick," I have given a revision of them in a recent paper on "The Earliest Winged Insects of America." The genus is remarkable for the length of the mediastinal vein, which is scarcely shorter than the scapular, for the absence of oblique branches of the same, for the absolute simplicity of the scapular vein, and for the small importance of the externomedian vein, which has only a few oblique generally simple branches occupying the apex of the wing.

Homothetus fossilis.

Homothetus fossilis SCUDD., Dev. Ins. New Brunsw., 17, pl. 1, figs. 1-2. Earlier references may be found in the synonomy there given.

Devonian beds of St. John, N. B.

Mixotermes Sterzel.

This genus, considered by Sterzel, not without some reason, as one of the Termitidae, seems to find its place here. Probably the mediastinal vein will be found to reach the margin not far beyond the middle of the wing, where the scapular vein, otherwise simple, first begins to send short branches to the border. The structure of the externomedian vein precisely accords with this family. What Sterzel considers the lower branch of the externomedian is probably the internomedian vein, while at least the lower of the veins considered by him as internomedian should be considered as anal.

Mixotermes lugauensis.

Mixotermes lugauensis STERZEL, Ber. naturw. Gesellsch. Chemn., VII, 273-276, pl., fig. 3-5.

Carboniferous deposits of Lugau, Germany.

Omalia Coem.-Van Ben.

Probably this form belongs here but the original needs a new study, as its curious venation is plainly impossible and no sufficient description has ever been given.

Omalia macroptera.

Omalia macroptera COEM.-VAN BEN., Bull. Acad. roy. Belg., (2), XXIII, iv, 384-401, pl.

Carboniferous deposits of Sars Longchamps, Belgium.

PALAEOPTERINA Scudder.

Wings obovate, several times longer than broad, the mediastinal vein of front pair terminating, usually not far from the middle of the wing, by running into the scapular vein.

The scapular vein throws off an inferior branch before the middle of the wing, generally close to the base, and runs past the extremity of the mediastinal without being affected by it; it usually reaches nearly the tip of the wing, but in some cases does not extend beyond the middle; the inferior branch is forked a few times, the branches, very longitudinal, rarely occupying more than the upper half of the tip of the wing. The externomedian vein is very unimportant, often simple, occasionally divided at the base into two stems, each of which may fork once or twice, and in one abnormal type assuming an importance equal to the main branch of the scapular vein. The internomedian vein nearly always extends so far as to occupy with its branches the whole of the lower margin; the main vein is sometimes strongly sinuous, and the branches are nearly always more oblique than in the Homothetidae, more numerous and arising somewhat continuously from the base outward. The anal vein is provided with many closely crowded, generally longitudinal branches, the area never reaching beyond the middle of the wing.

This account of the structure of the wing differs from that formerly given by me (Mem. Bost. Soc. Nat. Hist., I. 189) in some slight particulars only, due to the discovery of additional types.

The group differs conspicuously from the Homothetidae in the termination of the mediastinal vein, which impinges upon the scapular vein and not upon the margin of the wing. The relative importance of the externomedian and internomedian areas is reversed, and the contrast between the course of the branches in the two areas generally more marked here than in the Homothetidae. The importance of the internomedian area prevents the anal from encroaching beyond the middle of the wing. It differs from the Xenoneuridae principally in the structure of the lower part of the wing, in the complete independence of the externomedian vein, and in the conspicuous branching of the internomedian. The termination of the mediastinal vein separates it from the Hemeristina, as does the less importance of the scapular and externomedian areas. Apart from the termination of the mediastinal vein, the relation of the neuration to existing neuropterous families is much the same as in the Homothetidae. In this respect, however, it more closely resembles the Sialina and Perlina. From these it is separated by the decided deficiency of the scapular branch, whose offshoots rarely fall below the middle of the apex of the wing; by the unimportance also of the externomedian vein, which is usually simple; by the far greater extent and importance of the internomedian area, which may be considered the remarkable part of its structure, reaching out far toward the tip of the wing, and with the anal area occuping nearly half of the wing.

Gerstaecker has in various places claimed that their neuration would place the Palaeopterina in the Perlina, but nowhere specifies the reasons for this belief. The more perfect presentation of the family characteristics, which we are now able to give, shows that his claim is unfounded; indeed, the single point in which a special resemblance can be traced is in the distal union of the mediastinal and scapular veins, by the impinging of the former on the latter in the apical half of the wing; a feature which these two families share in common with the Embidina, Raphidiidae, etc. The externomedian vein, for example, is either simple or divided almost at the base in the Palaeopterina, while in the Perlina it runs undivided past the middle of the wing, separating two great fields, the one above devoid of cross veins, the one below cut, at least in one sex, by numerous prominent cross veins, and together forming a very distinct and characteristic feature having no sort of counterpart in Palaeopterina.

Most of the genera agree in the structure of the internomedian vein; but in one (Strephocladus) it is remarkable for throwing off its offshoots from its superior, and not inferior, side; while another type (Aethophlebia), which we have placed at the end of the series, is very remarkable throughout, though it would seem to fall in this place.

Miamia Bronsoni Dana.

Miamia Bronsoni DANA, Amer. Journ. Sc., (2), XXXVII, 34-35, fig. (1864).
Mazon Creek, Morris, Grundy Co., Ill.

Propteticus (πρωί, πτητικός) gen. nov.

Body apparently flattened, of moderate size, the thorax very broad but narrowing in front of the wings, the reduction falling on the mesothorax, the prothorax and head being narrow and prolonged. Abdomen apparently similarly slender. Mouth parts formed of a spreading tuft of organs extended in front of the head and in the same plane. Legs obscure but apparently rather long and slender, and increasing in size in passing backward. Wings large, full, oval, of nearly equal breadth excepting at extremities, at rest considerably overlapping the abdomen; the scapular vein prominently elevated, widely distant from the margin in the basal half of the wing, gradually approaching it in the distal half where the mediastinal vein soon falls into it, and terminating in the margin just before the tip; it has a single inferior branch arising near the base, which divides beyond the middle into two apically forked or simple branches. The externomedian vein divides at base into two long curved branches either simple or apically forked, which, with the branches of the scapular, occupy the whole of the apex of the wing. The internomedian and internal veins occupy nearly half of the wing, the former the outer and probably larger portion, with nearly straight, oblique, rather distant, simple veins. Straight or curved cross veins are scattered over the whole wing.

Like Miamia, this genus has a remarkable aspect from the narrowness of the head and prothorax as compared with the rest of the body. The mesothorax is broader than long and narrows rapidly, so as to be less than half as broad in front as behind, while the head and prothorax, each longer than broad, are parallel sided. Since the mouth-parts project forward in the same plane, the prolongation of the parts in front of the base of the wings is excessive, being considerably more than half as long as the body behind the front base of the wings, and perhaps as great as the extension of the abdomen behind the posterior base of the hind wings. The wings are ample and apparently folded upon the back as in modern Sialina. The hind wings appear to have been of the same general shape or a little broader, but without any special fulness of the anal area; this point, however, is very obscure from the imperfection of the fossil.

The genus differs from Miamia in the even greater slenderness of the head and prothorax, the anterior prolongation and tapering of the mesothorax, the larger anal appendages, and particularly in the neuration of the wings; viz., in the wider marginal field in advance of the scapular veins of the front wings, the arcuate course of the same vein, the much earlier origin of its inferior branch, and the much wider space between it and the main vein filled with stout, arcuate branches.

Propteticus infernus, sp. nov. Pl. 31, figs. 3, 4.

Head subquadrate, rounded behind and apparently a little broader than in front, nearly half as long again as broad, very slightly arched above, the eyes and antennae not appearing on the stone; the mouth-parts are nearly as long as the head itself, but do not admit of any clear separation of the parts; apparently, however, they consist of three pairs of very similar, single-jointed, moderately stout blades.

Prothorax similar in shape to the head, but a little larger, subquadrate with rounded angles, and apparently no broader behind than in front, transversely arched like the head, with a slight median carina obliterated in the centre. The head could apparently be partly withdrawn beneath it, since it seems to have been preserved in that condition, as the illustrations show, the front margin of the prothorax appearing to cut the head in halves in fig. 4, where it best appears; while in fig. 3 the hinder edge of the head is seen embraced at the sides by the edges of the prothorax, as is seen better still upon the stone. The front legs apparently are indicated by the scars on either side of the stone, especially by that on the left side of fig. 4 and its reverse, where a tibial joint appears to be marked. The legs are shown by this to have been rather short and very slender; toward the base of the detached scar of the right leg, in fig. 4, is seen the end of a slender femur, which appears even slenderer in the reverse (left side of) fig. 3.

The mesothorax is of a very strange form when taken in connection with the prothorax; it is half as broad again as long, and the wings are attached next the hinder margin, while the parts in front taper, as has been said, to the size of the prothorax, which is considerably less than half the posterior width of the mesothorax; the front margin is roundly excised as if forming a socket for the movement of the prothorax, and the tapering sides are gently convex; the surface does not appear, as in the parts in front, to be regularly arched, but to be furnished with coarse bosses, especially in the medial portions. Its legs are shown only on one side, and that very obscurely, indicating a length about the same as that of the front pair.

The dimensions of the metathorax can only be judged by the size of the legs and wings, the hind wings being ampler than the front pair, and the hind legs longer, so far as can be told from the scars, than either of the others; it can hardly be narrower than the mesothorax, and in all probability was of the same width; its legs, or rather the fracture-scars indicating where they were, are preserved on both sides of the body, and a basal fragment of that of the right side (in fig. 4) is actually preserved, showing again that they were very slender, compressed, and of considerable length, or much longer than either of the other pairs.

The indications of the abdomen are very vague, but show it to have been slender, nearly as broad at tip as the prothorax, and provided with a pair of rather slender, tapering, pointed anal appendages about as long as the mouth-parts.

Front wings broad, more than three times as long as broad, oblong oval, the middle half or more equal or very nearly equal, the apex very regularly rounded; costal margin a little shouldered near the base. Marginal vein bordered on the proximal half of the wing by a very narrow and tapering membrane, so that it does not form the actual margin until beyond the middle of the wings. Mediastinal vein parallel to it, impinging on the scapular a little before the end of the middle third of the wing, and running nearer the marginal than the scapular vein. Scapular vein gently arcuate, running in the proximal half of the wing in a straight course parallel to the marginal vein, then bending slightly upward to meet the top of the mediastinal, and in the apical third of the wing curving gradually downward, a little less rapidly than the marginal so as to unite with that not far before the extreme tip (which is broken off); very far toward the base of the wing (near the middle of the basal fourth) the inferior offshoot originates, and runs completely parallel to the marginal vein until it forks, at or just beyond the tip of the mediastinal vein; each of its forks again subdivides in the left wing, at no great distance from the border, the upper one more distant from it than the lower; but in the right wing the upper fork is simple, and the lower as in the opposite wing. The externomedian vein forks near the base, next the origin of the scapular branch, and its branches pass in a broad curve to the tip of the inner margin, the lower one simple, the upper forked apically, the fork being deeper on the right wing than on the left, where, in this feature, it stands midway between the two forks of the scapular branch. The internomedian vein is a little obscure except in the apical portion, where the veins originate a very little earlier on the left wing than on the right; it parts from the neighborhood of the other veins next the forking of the preceding vein, and passes first in a straight line to just about the centre of the wing, when it sends a straight oblique branch to the middle of the apical half of the lower margin; it then takes a course sub-parallel to the costal margin, very soon emits another similar branch, and finally forks opposite the tip of the mediastinal vein; whether it also emits some branches nearer the base is uncertain, but it is probable that either there is a single one thrown off close to the base, parallel to those beyond; or that all the nervules within the first distinct branch belong to the anal vein; these last nervules are obscure, but appear to repeat the course and separation of the internomedian veins.

Hind wings shaped as the fore wings, but more ample, extending at rest, like the fore-wings, beyond the tip of the abdomen, which reaches about the middle of the distal half. Little of the neuration can be made out, but the apical half of the scapular vein appears to be the same as in the front wing. The internomedian vein is strongly curved before it forks in a sense opposed to the general course of the curving veins; it first branches a little before the middle of the wing, and in sending out its three or more branches (a little nearer the base than in the front wing) it turns parallel to the costal margin, and its branches part at a much wider angle and pursue a much more transversely oblique course than in the front wing. The anal area is probably not any fuller than in the front wing, for the hind wing of the right side shows by its apical margin, beneath the front wing of the left side (a margin not shown in the figure), that if there were any fulness to its anal area it should appear beyond the costal margin of the left front wing.

Length of body, from extremity of head (exclusive of mouth parts) to tip of body (exclusive of anal cerci), 34.5 mm., of mouth-parts, 2.5 mm., of head, 3.25 mm., of prothorax, 5 mm., of mesothorax, 5.75 mm., of anal cerci, 2.5 mm., of front wing, 31 mm., breadth of head, 2.25 mm., of prothorax, 3 mm., of mesothorax, 9 mm., of front wing, 10 mm

This specimen is one of the most beautifully preserved of the fossil insects in nodules which I have seen. It was sent me for study by Dr. Jasper C. Winslow of Danville, Ill., to whom it belongs, and was found by him on Little Vermilion River, about four miles above Georgetown, Vermilion Co., Ill., in a carboniferous deposit. It is referred to as a species of Miamia in the Geology of Illinois, vol. IV, p. 253, where the relation of the deposit to the region is explained. The drawing by Mr. Blake is a very perfect representation of its appearance.

Dieconeura (διήκω, νεῦρον) gen. nov.

The wings of this genus are long and slender, largest beyond the middle. The mediastinal vein strikes the scapular vein considerably beyond the middle of the wing, while the main branch of the latter, bearing two or more simple or forked branches, which fill the whole apex of the wing, arises in the middle of the basal half of the wing. The externomedian vein is simple. The internomedian vein is very long, reaching nearly to the extremity of the lower margin, and sending at equal distances a number of simple oblique branches to the border. The anal vein with its branches occupies the basal third of the lower margin.

The simple externomedian vein, combined with the importance of the internomedian, are the striking features of this genus.

Dieconeura arcuata sp. nov. Pl. 30, fig. 4.

The scapular branch begins to fork beyond the middle of the wing, and is connected near here by an oblique cross vein to the externomedian vein, which is at first straight and divides equally the broad space in the middle of the wing between the scapular branch and the internomedian vein, but afterwards curves downward following the course of the extremity of the internomedian vein. The latter is strongly sinuous, taking at first a nearly straight course as if it would terminate at about the middle of its actual area, then curving upward into close proximity to the base of the first off-shoot of the scapular branch, and then turning to its former course, but arcuate; the main stem is bordered throughout by a dusky band intensifying its otherwise striking character. The abdomen is long and slender, the joints of nearly equal length and breadth. Length of thorax and abdomen 29 mm., of front wing 30 mm., width of same, 7.25 mm.

Carboniferous beds of Mazon Creek, Ill. Mr. R. D. Lacoe, No. 2043.

Dieconeura rigida sp. nov. Pl. 29, fig. 10.

All the veins are remarkably straight and stiff. The mediastinal strikes the scapular vein at an acute angle without bending down to it. The scapular branch has few and distant branches (two only are seen), the first arising far before the middle of the wing and forking near the origin of the second branch below the union of the mediastinal with the scapular vein. The externomedian vein is perfectly straight, filling the equal space between the internomedian vein and the scapular system. The internomedian vein is slightly bent near the middle of the wing and its simply oblique branches are slightly arcuate. The wing is the only part preserved and is very imperfect, showing only the middle of the wing. The length of the fragment is 11 mm.; probably the whole length of the wing was 20 mm., the breadth 6 mm.

From the interconglomerate beds of Pittston, Penn. Mr. R. D. Lacoe, No. 2012.

Strephocladus (στρέφω, κλάδος) gen. nov.

The wing is long, slender and nearly equal throughout. The mediastinal vein throws off distant and longitudinally oblique, more or less arcuate or sinuous branches to the margin in the basal half of the wing; in the apical half, in common with the mediastinal, frequent, straight and transversely oblique branches. The scapular branch arises shortly before the middle of the wing and sends several simple longitudinal branches to the upper half of the apex; it is connected close to the base to the otherwise simple externomedian vein. The internomedian vein is the most remarkable and characteristic; instead of following the course of the externomedian vein and emitting inferior offshoots, it runs to the middle of the lower border of the wing and emits from its superior surface a number of nearly straight simple or forked offshoots parallel to the externomedian vein, to which the uppermost is united by a few basal cross veins. The anal veins are numerous and arcuate.

Strephocladus subtilis

Petroblattina subtilis Kliver, Palaeontogr., xxix, 254, pl. 35, fig. 1.

The peculiarity of the internomedian vein wrongly led Kliver to consider this a cockroach, since Petroblattina presents a similar feature.

Carboniferous deposits of Schiffweiler, Germany.

Aethophlebia (ἀήθης, φλέψ) gen. nov.

A very remarkable and anomalous genus, particularly in the structure of the internomedian vein, and in the existence of an adventitious vein made up largely of a branch of the internomedian, and running across the externomedian vein into the main branch of the scapular vein in such a way as to appear a baseward continuation of it. The mediastinal vein strikes the scapular a little beyond, and the main scapular branch is thrown off a little before, the middle of the wing; the latter is at first parallel to the costal margin until, just below the tip of the mediastinal, it meets the adventitious vein, when it takes the upward course of the latter until it is in near proximity to the main vein; it emits three or four longitudinal, slightly declivent, parallel branches. The externomedian vein is coalesced with the internomedian at the base, then takes a straight, horizontal course to the adventitious vein, where it forks into two simple branches parallel to the scapular offshoots, the base of the fork forming part of the adventitious vein. The internomedian vein runs in a slightly tortuous course toward the middle of the lower margin of the wing and beyond its middle sends out obliquely upward the main branch which forms the adventitious vein, and from the lower surface of the branch and the outer surface of the main stem arise frequent straight and mostly simple branches like the scapular offshoots.

Aethophlebia singularis sp. nov. Pl. 31, fig. 9.

The single specimen is a nearly perfect wing, broadest in the middle, with the tip lost where it extended beyond the nodule. The straight mediastinal vein is at considerable distance from the nearly straight costal margin and connected with it by straight, transversely oblique, mostly simple veins which become more crowded toward the extremity, and where they arise from the scapular vein, which is sinuous and beyond the tip of the mediastinal approaches the margin. The interspace between these two veins is traversed by straight, transverse veins, but the other main interspaces are crossed by oblique and generally straight but sometimes arcuate and always simple cross veins; the offshoots from the scapular branch and adventitious vein are parallel to each other and equidistant, connected by straight, transverse veins in places (and probably everywhere), making quadrate cells in these narrower interspaces. The large triangular space between the middle portion of the externomedian vein (here straight and parallel to the costal border) and the internomedian and adventitious vein is broken by a sinuous, longitudinal vein parting from the externomedian, below which the cross veins are oblique, above, transverse. The anal veins are obscure, excepting the two outer principal ones which are close together, distant from, and sub-parallel to, the internomedian vein. The lower margin is gently convex. Length of fragment, 31 mm., probable length of the wing, 38 mm., breadth, 12 mm.

Carboniferous deposits of Mazon Creek, R. D. Lacoe, No. 2037.

Xenoneuridae Scudder.

The characteristics of this family have already been given by me in my paper on Devonian Insects.[1] It agrees best with the family just reviewed, in that the mediastinal vein impinges upon the scapular, and that the latter bears a principal branch with offshoots feeding the tip of the wing. But the externomedian vein is peculiar in being amalgamated for a considerable distance with the scapular, and then forking considerably and occupying the outer half of the lower margin; while the inner half is equally divided between the internomedian vein with its basally divided, simple branches, and the anal vein crowded against the border.

Xenoneura antiquorum.

Xenoneura antiquorum Scudd., Dev. Ins. New Brunsw., 24–29, pl. 1, figs. 5–7. Earlier references will be found there.

Devonian beds of St. John, N. B.

Hemeristina Scudder.

Wings elongate, the mediastinal vein simple, terminating on the costal margin beyond, generally far beyond, the middle of the wing. The scapular vein throws off an inferior

[1] Anniv. Mem. Bost. Soc Nat. Hist., 1880.

branch which arises before, generally far before, the middle of the wing, and runs sub-parallel to the main stem; from this branch arise a variable number of obliquely longitudinal, simple, or forked off-shoots, which generally occupy the whole of the apex of the wing, and sometimes infringe a little upon the lower margin. The externomedian vein generally extends nearly to the middle of the wing before branching, and then forks more or less abundantly, showing considerable variation in this respect, the nervules sometimes occupying the larger part of the outer half of the inner margin, sometimes reduced to a single branch or two. The internomedian vein resembles the preceding, although it branches from the the base and is generally more important than the externomedian vein where the latter is poorly developed, though sometimes it is simple. The anal veins generally occupy the basal fourth of the inner margin, with a series of simple, or simply forked, sub-parallel branches, generally arising close to the base of the main stem.

This group has been twice described and named by me—once in 1865[1] under the name of Hemeristina, when only a single and rather aberrant form was known to me; and again in 1880[2] under the name of Cronicosialina, when discussing the affinities of one of the Devonian forms. It now appears that not only these, but the series of wings discussed by me in a paper on English paleozoic insects (excepting one, Archaeoptilus, shown to belong in quite another place) should be brought together from possessing one important character in common, characteristic of the neuration of most plannipennians to-day, — the existence of a main scapular branch from which a considerable number of inferior offshoots arise and occupy the entire tip of the wing, or even more than that. In modern plannipennian Neuroptera it is usually more important than here, and the modern groups to which this series of forms bears most resemblance — the series allied to Sialis — differ in that the mediastinal vein impinges on the scapular and not on the costal margin. The ancient group can, indeed, only be looked upon as a generalized plannipennian type, as we have already pointed out in our discussion of the British forms (*loc. cit.*).

Other ancient groups, indeed, the Palaeopterina and Xenoneuridae, agree with it in the possession of a single, main scapular branch from which offshoots arise; but in each of these the offshoots are few in number and importance as compared to what is found in the Hemeristina: from them it further differs in the point of termination of the mediastinal vein, and the usually far greater importance of the scapular branch; while from the Palaeopterina it may also be distinguished by the minor importance of the internomedian vein, and from the Xenoneuridae by the more abundant neuration. Gerstaecker has referred Hemeristina positively to the Ephemeridae with which it has no more in common than have the other families here characterized, whose mediastinal vein terminates on the costa.

Lithomantis Woodward.

Prothorax with large, dilated, and rounded lateral lobes. Mediastinal vein of front wings running in very close proximity to the border, but farther from it in the middle than at the base of the wing. Internomedian area extensive, occupying the middle third of the lower margin, and fully as important as the externomedian area.

[1] Mem. Bost. Soc. Nat. Hist., I. 199.

[2] Devon. Ins. New Brunsw.

[3] Mem. Bost. Soc. Nat. Hist., III. 213.

Lithomantis carbonaria.

Lithomantis carbonarius Woodw., Quart. Journ. Geol. Soc. Lond., xxxii, 60–64, pl. 9, fig. 1.

Carboniferous deposits of Scotland.

Lithosialis Scudder.

Wings only known. Mediastinal vein of front wings moderately distant from the margin, gradually approaching it all the way from the base; internomedian area unimportant, and far less extensive than the externomedian.

Lithosialis Brongniarti.

Lithosialis Brongniarti Scudd., Mem. Bost. Soc. Nat. Hist., iii, 223.

Carboniferous deposits of Coalbrookdale, England. See the reference above for earlier synonymy.

Lithosialis bohemica.

Lithosialis bohemica Scudd., Proc. Bost. Soc. Nat. Hist., xxi, 167.

Gryllacris bohemica Novák, Jahrb. geol. Reichs., xxx, 69-74, pl. 2, figs. 1–2.

Coal measures of Stradonitz, Bohemia.

Lithosialis carbonaria.

Acridites carbonarius Germ., Münst., Beitr. zur Petref., v., 92-94, pl. 13, fig. 5;—Ib., Verst. Steink. Wettin. 87, pl. 31, fig. 10.

I place this species here from the close general resemblance of the neuration to that of the two preceding species. To do so, however, it is necessary to suppose an error in the figures given by Germar in making the mediastinal vein arise as a superior offshoot of the scapular; but as this correction seems necessary to any understanding of its neuration, it is not a violent supposition. Germar in his later work presumed it to be the hind wing of his Blattina didyma, but it does not at all agree with the neuration of the hind wings of any paleozoic cockroaches.

Carboniferous beds of Wettin, Germany.

Brodia priscotincta.

Brodia priscotincta Scudd., Mem. Bost. Soc. Nat. Hist. iii. 215-217, pl. 17, figs. 3-7. —Ib., Geol. mag., (2) viii. 293-295, 300, fig.

Carboniferous deposits at Tipton, England.

Pachytylopsis DeBorre.

There has been some dispute about the position of this genus, but I think there can be no doubt that its place is here. Through the kindness of Mr. DeBorre I have been able to examine not only the excellent heliotype he has published, but a cast from the fossil, by which it is evident that while the wing has much the general form and proportions of a modern Pachytylus its neuration is altogether different. The mediastinal vein ends in the margin a little beyond the middle of the wing. The strong and prominent gently arcuate scapular terminates at the upper tip; from it is thrown off before the middle of the basal half of the wing a simple branch parallel to itself, which supports numerous, parallel, oblique branches, the innermost of which strikes the middle of the outer half of the lower border. The externomedian and internomedian offshoots, similar and parallel to those of the scapular branch, are comparatively insignificant and divide about equally between them the space between the scapular and anal veins, which latter strikes the lower margin below the origin of the first offshoot of the scapular branch. An additional proof of its position here is the presence of a long longitudinal cross-vein uniting the base of the main scapular branch with the externomedian branch, as in Brodia.

Pachytylopsis Persenairei. Pl. 31, fig. 7.

Pachytylopsis Persenairei DeBorre, Ann. Soc. Ent. Belg. XVIII, 56, pl. 5, fig. 1; — GIARD, Bull. Sc. Hist. Litt. Nord, VII, 121-122. — VAN VOLXEM, Comptes Rend. Soc. Ent. Belg. (2) XXIV, 20-26.

Carboniferous beds of Mons, Belgium.

Lithentomum Scudder.

This genus differs from all the others placed in this group in the presence of only a single offshoot of the scapular branch; and although this point is uncertain from the imperfect nature of the single fragment, it seems improbable from what is preserved that more can find a place. It agrees, however, in all other features with the family and seems to find its place here.

Lithentomum Harttii.

Lithentomum Harttii SCUDD., Dev. Ins. New Br., 22-24, pl. 1, fig. 3, where earlier references are fully given;—HAGEN, Bull. Mus. Comp. Zool., VIII, 278; SCUDD., Earl. Winged Ins. Amer., 4, pl. fig. 2-3.

Devonian beds of St John, New Brunswick.

Chrestotes Scudder.

The termination of the mediastinal vein in the border and not in the scapular shows that this insect cannot be referred to the Palaeopterina as formerly supposed by me. Its place seems to be here in the neighborhood of Hemeristia, though it differs widely from that in the character of the scapular branch, and is peculiar for the deep impression of the principal anal vein.

Chrestotes lapidea. Pl. 31, fig. 2.

Chrestotes lapidea SCUDD., Geol. Surv. Ill., III, 567, fig. 2.

In the figure formerly given the engraver obscured the venation by numerous lines parallel to the veins. The one now given is from a sketch taken by myself at that time.

Carboniferous beds of Mazon Cr., Morris, Illinois.

Hemeristia occidentalis.

Hemeristia occidentalis DANA, Amer. Journ. Sc., (2) XXXVII, 35, fig. 2;—SCUDD., Amer. Journ. Sc., (2) XL, 269-271; — IB., Mem. Bost. Soc. Nat. Hist., I, 191-192, pl. 6, figs. 1, 3; — IB., Geol. Mag., V, 217-218.

Same deposits.

Apparently allied to this, but too imperfect to warrant confidence in a definite statement, is an insect (pl. 31, fig. 8) from the same deposits, received from Mr. R. D. Lacoe under the number 2050. It certainly differs from the preceding in the development and structure and curving disposition of what appear to be the internomedian vein; but the outer half of the wing being lost, no scapular branch can be seen, although one would look for it in the portion preserved. The course of what appear to be the externomedian offshoots — at least as seen on the left side — lead one to suppose that such a branch (or branches) must exist, and the general appearance of the insect is that of this family. The head is transverse, well rounded and strongly convex, and obscure parts in front of it take on a triangular form.

GERARINA fam. nov.

Wings variable in form but usually not so elongate as in the other types, and sometimes remarkably short in proportion to their width. The mediastinal vein is simple, runs close to and terminates in the margin, usually far toward the tip of the wing, and sends numerous oblique offshoots to the margin. The scapular is generally the most important vein in the wing, running parallel to the mediastinal, and emitting several or many longitudinally oblique branches, most of them generally in the outer half of its course; these branches may be perfectly simple, the outermost forked a little, or all more or less forked, and then liable to appear arborescent; even when most numerous they rarely occupy more or much more than the tip of the wing, on account of their longitudinality and their lack of tendency to spread. The externomedian vein is generally less, often far less, important than the scapular, and has two or more branches, the offshoots running parallel to those of the preceding vein, which they resemble so as to be indistinguishable from them when their origin is concealed; the innermost branch never strikes the margin in the basal half of the wing. In one curious type (Megathentomum) this seems to be the most important vein in the wing, and all its branches fall on the broad apical margin. The internomedian vein is generally reduced to a simple vein, or to a lesser imitation of the externomedian vein. The anal area generally extends to or beyond the middle of the lower margin of the wing, and seems usually to be filled with more or less oblique and more or less frequent nervules running to the margin.

This family differs from all the preceeding in that the scapular vein has a considerable number of offshoots depending from the main vein itself and not from a simple principal branch. Nor is there any modern type to which it can be compared. A considerable proportion of the forms are now for the first time described, and all are American, excepting one which is very closely allied to an American form, falling into the same genus, which is in many respects widely different from the other types.

Polyernus (πολυς, ερνος) gen. nov.

Body apparently of moderate stoutness, the wings large and rather broad, well rounded. Mediastinal vein at a tolerable distance from the front margin, to which it sends many curving branches, and extending nearly to the tip of the wing. Scapular vein with three or four distant, inequidistant, but very longitudinal, and therefore closely crowded, ramose branches, the lowermost falling but little below the tip of the wing. Externomedian numerously branched but less ramose, of about equal importance with the preceding. Internomedian with numerous inferior, mostly simple branches, occupying the middle half of the lower margin. Anal veins similar.

Polyernus complanatus, sp. nov. Pl. 32, figs. 8, 11.

The prothorax forms a sort of depressed shield like that of a cockroach, and is tolerably well preserved, showing that it was subquadrangular, narrowing anteriorly, with well rounded front and rounded posterior angles, a little broader than long, the posterior margin convex; the whole surface was rugose, but especially over a large, subcentral but posterior, subcircular boss, the cast of which shows a depression filled with coarse, low granules. The wings are very large and long, evidently extending far beyond the tip of the abdomen, and overlapping, in the single example known, so that it is difficult to separate them, or to distinguish certainly to which wing each belongs. From a careful study, however, it would appear that the mediastinal extends nearly or quite to the tip of the wing (which is lost); that the scapular throws off three long and slightly curving, forked, or multiple forked, offshoots; and the externomedian three or four more oblique, but not more curving, simple, or simply forked, branches. Length of prothorax, 7 mm., breadth of same, 9 mm., breadth of mesothorax, 9.5 mm., length of fragment of wing, 36 mm., probable length of wing, 46 mm., apparent breadth of the same, 12 to 14 mm.

Mazon Creek, Ill. Received from Mr. R. D. Lacoe, No. 2058.

Polyernus laminarum, sp. nov. Pl. 31, fig. 1.

The four overlapping wings are alone preserved, the base lost and the whole somewhat obscure; the tips of all are roundly pointed. The mediastinal vein is much farther removed from the margin in the hind than in the front wing, and shorter; in the front wing it reaches only the rapidly declivent portion of the margin before the tip; the branches both of the scapular and externomedian veins have a strong, but graceful, downward sweep in the apical third of the wing; and the two basal offshoots of the former are forked just on a line (slightly oblique) with the singly forking externomedian branches, and just before the commencement of the downward curve of the nervules; the outer branches of the scapular vein are very ramose, in rather strong contrast to the simple forking of the externomedian branches. Length of fragment 50 mm., breadth of same 30 mm., probable length of wing 65 mm., its probable breadth 23 mm.

A single specimen and its reverse, Nos. 2012, 2013, were received from Mr. R. D. Lacoe. They are from a thin shale interleaved in the conglomerate near Pittston, Penn. (No. XII of Roger's Survey of Penn.), and very near its base, there being but six or eight feet of coarse pebbly rock between this shale and the "red shales" beneath.

Gerarus (γεραρός) gen. nov.

Body slender and elongated, the prothorax rapidly narrowing in front, so that the head is probably narrow and elongated. Wings correspondingly slender, well rounded, but with tips not produced. Mediastinal vein at a considerable distance from the front margin, united to it by many arcuate cross veins, and extending a variable distance toward the tip, but always to some distance beyond the middle. Scapular vein with a considerable number of longitudinal, more or less oblique, simple or forked offshoots, making it by far the most important vein in the wing, the internomedian and anal veins apparently dividing the remaining space about equally between them.

Gerarus vetus, sp. nov. Pl. 31, fig. 6.

The mesothorax appears to be broader than long, the prothorax rounded subtriangular, and in front of it a linear prolongation more than three times as long as broad, which may be the head, or a prolongation of the prothorax; in front of this the stone shows a blackish discoloration. The wings are broadly rounded at the apex. The mediastinal vein extends nearly or quite to the tip; the scapular vein, arcuate and separating itself gradually from the former, again sweeps toward it past the middle of the wing, and throws off a large number of mostly simple, parallel, oblique branches, the earliest of which must strike the lower margin not far from the middle of the hind margin; transverse cross veins are to be seen throughout in the minor interspaces. Length of whole preserved portion 71 mm., of head (?) 11 mm., breadth of same, 3 mm., breadth of mesothorax 10 mm., length of wings, 52 mm., breadth across the partly opened wings 23 mm., breadth of wing 19 mm.

Mazon Creek, Ill. Received from Mr. J. W. Pike and now in the collection of Mr. R. D. Lacoe under the number 2054.

A much smaller but very imperfect fossil, figured on pl. 32, fig. 3, appears to belong in this neighborhood, but to be distinct from anything known. Nearly all the numerous nervules of the scapular and lower veins are straight, simply and early forked, parallel and oblique. A future find may enable us to place it more exactly. The length of the fragment is 30 mm., the probable length of the wing about 40 mm., and its probable breadth about 15 mm. It comes from Mazon Creek and bears the number 2016 in the cabinet of Mr. R. D. Lacoe, to whom I am indebted for the opportunity of seeing it.

Gerarus mazonus, sp. nov. Pl. 32, fig. 7.

The body is much elongated, but is very imperfectly preserved, patches only or obscure indications of it appearing at various places. There seems to be a transversely rounded granulated prothorax, in advance of which is a longitudinally ovate head, shaped like that of Eugereon, and in advance of that the base of a tube-like prolongation, which is almost immediately broken at the end of the nodule in which it is embedded, and is half as broad as the head. The abdomen is slender and the wings long and slender with scarcely produced rounded tips. The neuration is imperfectly preserved, and in some parts it is difficult to determine whether certain veins belong to the upper or under wings, but it would appear as if the mediastinal vein were shorter than usual, not reaching the middle of the outer half of the wing, and that the scapular vein had four or five forking and curving branches, which occupied nearly one half the area of the wing. The neuration would appear to bring the species in this group, and I have accordingly placed it here, but with reserve. Length of body from front of head (excl. appendages) to tip of abdomen 15 mm., of head 3.5 mm., breadth of same 2 mm., apparent breadth of prothorax 6 mm., apparent length of same 4.5 mm., probable length of wing 12 mm., breadth of same 12 mm., width of abdomen 3.5 mm.

Mazon Creek, Ill. Found by Mr. F. T. Bliss and now in my collection.

Perhaps in this vicinity comes another moderately slender species (pl. 32, fig. 5) which is very imperfectly preserved. Very little of the wing structure can be made out, but the general arrangement seems to be much as in Gerarus and to be most nearly allied to what is found in the preceding species. The wings are about 20 mm. long. It comes from Mazon Creek, where it was obtained by Mr. F. T. Bliss.

Gerarus Danae. Pl. 31, fig. 5.

Miamia Danae SCUDD., Geol. Surv. Ill., III, 566, fig. 1.

This species differs from the others placed here by the longitudinal disposition of the veins, which have little obliquity in them. The mediastinal vein extends nearly to the tip; the apical scapular branch is compound, but the others simple; a few cross veins may be seen. It is the smallest species in this genus. The body is very vague but shows enough to prove that it was much elongated. The thorax looks as if it had a median furrow. The wings were apparently about 25 mm. long; their breadth is 8 mm.

Carboniferous deposits of Mazon Creek, Illinois.

Adiphlebia (α-, δίς, φλέβιον) gen. nov.

Body rather stout, of subequal breadth throughout the thorax and basal two-thirds of the abdomen, the latter tapering apically, and the obscure parts in front of the prothorax triangular and about as long as one of the thoracic joints. Wings rather broad, well rounded, with straight costa. All the nervules arising from the main stems in the basal third of the wing and extending without any forking, sub-parallel, scarcely divergent, straight and longitudinal throughout the wing, giving it a very unusual appearance.

Adiphlebia Lacoana, sp. nov. Pl. 32, fig. 6.

The mediastinal vein runs to the declivent portion of the costal margin, the scapular in close proximity to it, throwing off three branches only, close together at the root of the wing, which run parallel to each other unbroken to the tip, where they do not fall below the middle. It is impossible to tell to which veins all the subsequent similarly simple nervules belong, as they also part from one another and their main veins at the very root of the wing. Length of body 31 mm., of abdomen 17 mm., breadth of body 5.25 mm., length of wing 25 mm., its width 9 mm.

Mazon Creek, Ill. R. D. Lacoe, No. 2057.

Megathentomum Scudder.

This genus has certain relations to the preceding, since most of the branches, which are apically formed, must, in most instances, to judge of their direction by the only fragments which are known, have originally parted from the main stem very near the base. The branches are, however, very few in number, and the wing remarkably broad, rounded and large, the main scapular vein branching only near the tip, and the vein there bent upward as if it were a superior branch and the first branch the main vein. Two species are known, one from this country and one from Germany.

Megathentomum pustulatum. Pl. 32, figs. 1, 9, 10.

Megathentomum pustulatum Scudd., Proc. Bost. Soc. Nat. Hist., xi, 401–402; Ib., Geol. Surv. Ill., iii, 570, fig. 7.

The original specimen (fig. 1) is the best that has been found, so far as I know, but several others have been discovered, one of which is figured here. The wing was exceedingly broad, indeed, probably more than half as broad as long. It was broadest beyond the middle and subtriangular in shape, though the outer margin was fully rounded. The mediastinal vein was long, terminating shortly before the declivent termination of the straight costa, and emitting several very oblique and nearly straight branches to it. The scapular vein, parallel to the latter, first branches near the tip of the latter, sending out one or two simple or forked branches which support the upper tip of the wing. The externomedian vein occupies the middle third of the wing, and occupies the largest area, dividing into three branches near the base of the wing, each of which forks singly and rather widely near the border, and at varying distances from it. The internomedian vein divides more than once and supports the lower outer angle of the wing.

In this specimen there are six larger, round or squarish, discolored spots, the surfaces irregularly elevated or blistered; four of them form a bent row in the middle of the outer half of the wing, the upper three spots being nearly straight and the lower one turned inward at a little more than a right angle; the uppermost spot occurs in the scapular-externomedian interspace; the others follow in succeeding interspaces. The two other large spots are found in the same interspace with the upper two of the inner row and are situated about half way between them and the border. There are also many smaller spots, often deeper in tint and not elevated, which appear to be less regularly distributed; they are usually round but sometimes oval or transversely elongated; there are three at equal distances from one another in the lower interspaces formed by the branches of the scapular vein, another occurs just within and above the inner of these three, and one in the angle of the last branch of the scapular vein; there are two between the forks of each of the upper branches of the externomedian vein, and one near the margin between these two forks; two larger and elongated spots occur in the same interspace with the lowest of the larger spots, at equal distances on either side of it, and the outer close to the margin of the wing; three equidistant ones are seen in the fork of the upper internomedian branch, one near the middle of the hind border, and finally two faint ones in the middle of the wing situated beneath and against the upper branches of the externomedian vein.

In the other fragment particularly studied (fig. 10) there are two large spots, as before, in the scapular-externomedian interspace, but they are more widely separated; a single large one in the interspace beneath, situated mid-way between the two; but one of intermediate size, though apparently belonging to the larger series, in the same interspace nearly half way between the inner and the margin. The smaller spots are distributed in a very irregular and evidently meaningless way; they are less frequent than in the first specimen found, but on the other hand there is a third series of mere dots, to the number of twenty or more, scattered about the apical part of the wing in the scapular area and just above it, below the apical branch of the mediastinal vein. A point unnoticed in the previous specimen, and perhaps from its preservation not discernible, is the fine but pronounced serration of the entire costal margin (fig. 9), which is armed with a close-set series of conical dentations, two or three times longer than broad, and separated by about their own width from each other; they are about 0.35 mm. long.

The wing in both specimens is of a dark brown color, the spots blackish brown, and the interspaces broken by a fine weak tracery of delicate irregular veins, having a general transverse disposition.

The smaller fragment is 57 mm. long and 23.5 mm. broad; the larger 55 mm. long and 46 mm. broad, the latter being the breadth of the wing, the length of which was not far from 80 mm. The smaller fragment appears to belong to an even larger wing.

The original specimen was sent to me by Prof. A. H. Worthen, through Mr. L. Lesquereux, and came from Mazon Creek, Ill. The smaller came from the same place and was sent me for study by Mr. Lacoe, in whose collection it bears the number 2025.

Meganthentomum formosum.

Acridites formosum GOLD., Fauna Saraep. Foss., II, 18-20, pl. 2, fig. 18.

Megathentomum formosum SCUDD., Proc. Bost. Soc. Nat. Hist., XVIII, 359.

This species differs from the preceding in the absence of spots and dots, and in having a more rounded and less triangular form and a more abundant branching, the externomedian vein having four principal offshoots and thirteen ultimate veinlets against scarcely more than half that number in the American form. Both have the same weak reticulation and are of about the same size.

Fischbach, Germany.

[Hemipteroid Palaeodictyoptera.]

A

Eugereon Böckingi.

Eugereon Böckingi DOHRN, Palaeontogr., XIII, 333–340, pl. 41

Permian deposits of Birkenfeld, Germany.

B

Fulgorina Ebersi.

Fulgora Ebersi DOHRN, Paleontogr., XVI, 131-133, pl. 8, fig. 2.

Fulgorina Ebersi GOLD., Faun. Saraep. Foss., II, 28-30, 51, pl. 1, figs. 16-17.

Carboniferous deposits of Saarbrücken, Germany.

Fulg. lebachensis Gold. and *F. Kliveri* Gold. are probably hind wings of Palaeoblattariae. I may remark that Goldenberg left behind him a drawing, now in my possession, in which he tried to restore the latter so as to make it fit the wing of a Gerablattina. *Macrophlebium Hollebeni* Gold. seems to me also most probably the hind wing of a cockroach, and the supposed separation line between a basal and distal area (corium and membrane) an accidental circumstance.

C

The two forms conceded above to belong in this section of Palaeodictyoptera seem to foreshadow the homopterous rather than the heteropterous division of hemipterous insects. The reverse is the case with the interesting species next to be described.

Phthanocoris occidentalis (φθάνω, κόρις) gen. et spec. nov. Pl. 32, fig. 4.

Phthanocoris occidentalis Scudd., Proc. Bost. Soc. Nat. Hist., xx, 58-59.

A perfect front wing of moderately large size, nowhere very broad, and less than three times as long as broad. The corium occupies rather more than three quarters of the wing, separated from the membrane by an oblique sinuous line running from a point on the lower margin about three-fifths the distance from the base, and reaching the costal margin only a little before the tip. Beyond the basal fourth the costal margin is very regularly and gently arched. The inner margin is strongly rounded next the base, beyond that to the end of the corium straight, with a scarcely perceptible turn outward where it strikes it; beyond this forming with the apical margin a regularly convex curve, the apex of the wing falling in the middle of the upper two-thirds and the greatest breadth of the wing being twice its width near the base. All the principal veins are stout and prominent, but especially is this the case with the mediastinal and scapular. The marginal vein forms the costal border. The mediastinal is simple and follows the curve of the margin, constantly and very gradually approaching it and finally blending imperceptibly into it just before the extremity of the corium, or in the middle of the downward slope of the margin. The scapular vein is the stoutest and most prominent in the wing; it originates scarcely above the middle of the base (the mediastinal midway between it and the margin), and runs parallel to the mediastinal until it divides, a little beyond the basal third of the wing; its inferior branch here recovers the straight course of the extreme base of the vein and retains it to the extremity of the corium, scarcely turning upward at the end and gradually losing its prominence; while the upper branch or main vein curves upward, very gradually and very slightly approaching the mediastinal vein until it reaches the upper limit of its convexity, and then runs parallel to it, terminating in the margin at the extremity of the corium. The externomedian vein originates just below the middle of the base of the wing and runs in a straight course down the middle of the wing to the end of the corium; it is the least prominent vein in the wing but occupies most space, filling the area below it with somewhat approximate, parallel, straight, oblique veins, most or all of which originate from a principal branch which runs parallel and near to the main vein. The internomedian vein, or sutura clavi, runs from the base of the last vein to the inner extremity of the corium a little beyond the end of the middle third of the wing in a straight line, curving very slightly toward the margin at the extremity of its course. The anal vein, starting from the same point, runs parallel to the inner margin throughout its basal curve and as far from it as the mediastinal from the marginal, and after that runs in a straight line to the tip of the sutura clavi, or almost exactly parallel to the inner margin. The margin of the membrane is filled from a quarter to a third its breadth with crowded, parallel, straight veinlets, which appear to arise vaguely from irregularly arborescent interlaced veins originating from the margin of the corium, at subequidistant intervals, which are about equal to those between the oblique branches of the internomedian vein. The surface of the clavus and corium has a minutely wrinkled appearance, not shown in the figure, formed of faint, crowded, transverse lines; these are most distinct upon the clavus; the surface is of a pale brown color, a little iridescent excepting where along some of the veins it appears to be covered with a clay brown film. The length of the wing is 15.75 mm., and its greatest breadth 5.75 mm.; a minute fragment of the tip is all that is not preserved.

It was found in the upper coal measures of Kansas City, Mo., in a small nodule in the blue and bituminous shales, forming layer 95 of the general section given by Broadhead in Pumpelly's Geological Report, ii. 88-97 (1873), and was received for examination from Mr. R. D. Lacoe under the number 2030.

The discovery of this fossil in carboniferous beds is a very remarkable one, for up to its discovery not only was no hemipteron known from rocks earlier than the tertiary in America, but no heteropterous hemipteron had been found anywhere in paleozoic formations. Yet the structure of the wing shows it to be distinctively heteropterous. The separation of the corium and membrane and the differential character of their structure is as clearly marked, apparently, as in existing types; the corium, it is true, is usually large in proportion to the membrane, and the clavus is very narrow; moreover while unquestionably divided into areas as in modern Heteroptera, their characters are very different. The sutura clavi for instance, instead of arising far toward the costal margin above the middle of the base of the wing, originates as in most ancient insects considerably below it; and the clavus, instead of being a broad field of a quadrangular shape (the opposing suturae clavi often forming a secondary triangular projection similar to the scutellum), is a narrow, elongated, triangular field of very slight importance and scarcely affecting the shape of the wing, especially as the sutura clavi terminates not before but at the extremity of the corium. Then the membrane, as stated, is very small, somewhat as in Zaitha, and indeed there is no group of Heteroptera to which it can be so well compared as to the aquatic reduvioid subfamily Belostomidae, one of the lowest groups of Heteroptera, though it certainly cannot be brought within the limits of any existing family. Another striking feature is the basal width of the margino-mediastinal, and mediastino-scapular interspaces, a feature almost or quite unknown in Heteroptera though not so uncommon in the Homoptera. We see, therefore, in the structure of this wing inherent signs of its antiquity — of its alliance to the earliest types of Homoptera and of less degree of divergence from other ancient types. No signs whatever of any approach to an embolium or cuneus are present, showing that in this as in other respects differentiation of the wing had not proceeded very far. Still the actual differentiation into the three grander areas is an indisputable fact which is very surprising; and adds another to the many startling instances already known, where a deep seated difference of structure has appeared abruptly so far as any evidence in wing structure or discovery in the rocks can point out.

A few species which have been mentioned, figured or described as coming from paleozoic rocks have not been introduced above and may here be briefly referred to: —

Euphemerites primordialis Scudd. (Proc. Bost. Soc. Nat. Hist., XIX, 248–249), is no insect at all, but the half of a leaf of Cyclopteris.

The three species which I described briefly and figured poorly in the Geol. Surv. Ill., vol. III, under the generic name of Ephemerites (wrongly printed Euphemerites) are also probably plants.

Libellula carbonaria Scudd. (Can. Nat., (2) VIII, 88–89, fig.), as a recent examination shows, is more probably the abdomen of an Arachnid, one of the Anthracomarti.

Termitidium amissum Gold. (Faun. Saraep. Foss., II, 17, pl. 1, fig. 6), is too fragmentary to be of any value, and it would be impossible to determine its position.

Termitidium rugosum Gold. (Ibid. pl. 1, fig. 14), which Dohrn first described as perhaps the remains of an orthopteron (Palaeontogr., XVI, 134, pl. 8, fig. 4), shows no vein attachments, and is, therefore, of very uncertain position.

Corydaloides Scudderi Brongn., (Bull. Seances Soc. Ent. France, 1885, p. xiii) has not yet been figured and the description of it is only provisional, so that its precise position cannot be discussed at present. A photograph Mr. Brongniart has kindly sent me shows that it is an interesting insect.

I venture to add the figure of an obscure fossil (pl. 32, fig. 2) showing most of the veins of the two overlapping wings, but generally without their attachments, so that their relation to each other cannot be determined; it is impossible to say until further material is at hand where it belongs. It was found by Mr. R. D. Lacoe near Pittston, Penn., in coal C of the Boston Mine and bears the number 2029 in his collection.

A species to which I had given the MS. name of *Termes longitudinalis* (see Lacoe's list of paleozoic insects, p. 15) is omitted here, because from an accidental circumstance it could not be obtained for reëxamination before the plates went to the engraver. It is not a Termes and will be considered on a future occasion.

Explanation of the Plates.

Plate XXIX.

Fig. 1. *Gerapompus blattinoides*, $\frac{3}{1}$, Mazon Creek, Ill. Drawn by J. H. Blake.
Fig. 2. *Archegogryllus priscus*, leg, $\frac{3}{1}$. Talmadge, Ohio. Drawn by S. H. Scudder.
Fig. 3. *Archegogryllus priscus*, wing, $\frac{+2}{1}$. Talmadge, Ohio. Drawn by J. H. Emerton
Fig. 4. *Eucaenus ovalis*, $\frac{4}{1}$. Mazon Creek, Ill. Drawn by Katherine Peirson.
Fig. 5. *Gerapompus extensus*, $\frac{3}{2}$. Mazon Creek, Ill. Drawn by Katherine Peirson.
Fig. 6. *Didymophleps contusa*, $\frac{1}{1}$. Vermilion Co., Ill. Drawn by J. S. Kingsley.
Fig. 7. *Cheliphlebia elongata*, $\frac{4}{1}$. Mazon Creek, Ill. Drawn by Katherine Peirson.
Fig. 8. *Gerapompus extensus*, $\frac{3}{2}$. Mazon Creek, Ill. Drawn by Katherine Peirson.
Fig. 9. No. 2055. See p. 325. $\frac{2}{1}$. Mazon Creek, Ill. Drawn by S. F. Denton.
Fig. 10. *Dieconeura rigida*, $\frac{2}{1}$. Pittston, Penn. Drawn by J. S. Kingsley.
Fig. 11. *Genopteryx constricta*, $\frac{2}{1}$, Mazon Creek, Ill. Drawn by Katherine Peirson.

PLATE XXX.

Fig. 1. *Anthracothremma robusta*, No. 2052, $\frac{4}{1}$, Mazon Creek, Ill. Drawn by Katherine Peirson.
Fig. 2. *Genentomum validum*, front wing, $\frac{4}{1}$, Mazon Creek, Ill. Drawn by Katherine Peirson
Fig. 3. *Genentomum validum*, hind wing, $\frac{2}{1}$, Mazon Creek, Ill. Drawn by Katherine Peirson
Fig. 4. *Dieconeura arcuata*, $\frac{2}{1}$, Mazon Creek, Ill. Drawn by Katherine Peirson.
Fig. 5. *Anthracothremma robusta*, No. 2052, $\frac{4}{1}$, Mazon Creek, Ill. Drawn by Katherine Peirson
Fig. 6. *Anthracothremma robusta*, No. 2018, $\frac{1}{1}$, Mazon Creek, Ill. Drawn by Katherine Peirson
Fig. 7. No. 2018. See p. 329, $\frac{2}{1}$, Mazon Creek, Ill. Drawn by Katherine Peirson.
Fig. 8. *Cheliphlebia carbonaria*, $\frac{2}{1}$, Mazon Creek, Ill. Drawn by Katherine Peirson

PLATE XXXI.

Fig. 1. *Polyernus laminarum*, $\frac{1}{1}$, Pittston, Penn. Drawn by J. H. Emerton.
Fig. 2. *Chrestotes lapidea*, $\frac{1}{1}$, Mazon Creek, Ill. Drawn by S. H. Scudder.
Fig. 3. *Propteticus infernus*, anterior extremity, reverse of fig. 4, $\frac{2}{1}$, Little Vermilion River, Ill. Drawn by J. H. Blake.
Fig. 4. *Propteticus infernus*, reverse of fig. 3, $\frac{2}{1}$, Little Vermilion River, Ill. Drawn by J. H. Blake.
Fig. 5. *Gerarus Danae*, $\frac{1}{1}$, Mazon Creek, Ill. Drawn by S. H. Scudder.
Fig. 6. *Gerarus vetus*, a little enlarged, Mazon Creek, Ill. Drawn by S. H. Scudder.
Fig. 7. *Pachytylopsis Persinairei*, $\frac{2}{1}$, Mons, Belgium. Drawn by S. H. Scudder from the heliotype published by DeBorre.
Fig. 8. No. 2050. See p. 342, $\frac{1}{1}$, Mazon Creek, Ill. Drawn by Katherine Peirson.
Fig. 9. *Aethophlebia singularis*, $\frac{4}{1}$, Mazon Creek, Ill. Drawn by Katherine Peirson.

PLATE XXXII.

Fig. 1. *Megathentomum pustulatum*, $\frac{1}{1}$, Mazon Creek, Ill. Drawn by S. H. Scudder
Fig. 2. No. 2029. See p. 350, $\frac{2}{1}$, Pittston, Penn. Drawn by J. S. Kingsley.
Fig. 3. No. 2016. See p. 341, $\frac{2}{1}$, Mazon Creek, Ill. Drawn by Katherine Peirson
Fig. 4. *Phthanocoris occidentalis*, $\frac{3}{1}$, Kansas City, Mo. Drawn by J. H.Blake.
Fig. 5. See p. 345, $\frac{2}{1}$, Mazon Creek, Ill. Drawn by J. S. Kingsley.
Fig. 6. *Adiphlebia Lacoana*, $\frac{2}{1}$, Mazon Creek, Ill. Drawn by S. F. Denton.
Fig. 7. *Gerarus mazonus*, $\frac{2}{1}$, Mazon Creek, Ill. Drawn by J. S. Kingsley.
Fig. 8. *Polyernus complanatus*, reverse of fig. 11, $\frac{2}{1}$, Mazon Creek, Ill. Drawn by S. F. Denton.
Fig. 9. *Megathentomum pustulatum*, showing the serration of the costal margin of fig. 10 near tip, $\frac{40}{1}$. Mazon Creek, Ill. Drawn by J. S. Kingsley.
Fig. 10. *Megathentomum pustulatum*, $\frac{1}{1}$, Mazon Creek, Ill. Drawn by J. S. Kingsley.
Fig. 11. *Polyernus complanatus*, $\frac{2}{1}$, reverse of fig. 8, Mazon Creek, Ill. Drawn by S. F. Denton

XIII. Winged Insects from a Paleontological Point of View, or the Geological History of Insects.

By Samuel H. Scudder.

Read April 1, 1885.

THE division of hexapod insects into orders has undergone no very striking changes since the time of Linné and Fabricius, the founders of entomological science; new elements, indeed, have entered into their definitions, but the main divisions introduced by these pioneers have, on the whole, stood the test of time and increasing knowledge in a somewhat remarkable way. Unquestionably this is due in large measure to a somewhat unusually sharp delimitation of most of the main groups, recognized even by the least observant, who, if given a thousand chance insects from his own neighborhood, would be pretty sure to separate from one another the wasps, the moths, the flies, the beetles, etc., or at least most of them. There are, of course, a few forms (few, compared to the mass) which would prove disturbing elements, and there are some concerning which the best informed are not wholly agreed. There are also some groups about whose taxonomic value there is still disagreement, such as whether the Heteroptera and Homoptera should be looked upon as orders or as primary divisions of the order Hemiptera; others concerning which there is some dispute whether they should be separated as orders, or as mere families of one of the long established orders, instances of which may be found in the Westwoodian orders of Aphaniptera and Euplexoptera; still others, not regarded as distinct orders, concerning whose nearest affiliation there is or has been question—as in the case of the so-called Pseudoneuroptera. This is in effect only to say that here, as in other great zoological divisions, there are aberrant groups, and the main groups themselves are unequally delimited.

The attempts, however, to group the orders into larger divisions still subordinate to the grand hexapod type have resulted in very diverse presentations, according as one or another set of organs, or other peculiarities, were deemed of prevailing weight. The two which have found the most adherents have been that which separated the mandibulate from the haustellate insects, and that which divided them from each other according as their metamorphosis is complete or incomplete. To the first, the objection naturally arises that it places the Hemiptera beside the Hymenoptera, Lepidoptera and Diptera, rather than with the Coleoptera and Orthoptera, to which by all other points in their bodily structure and by their metamorphoses they are certainly far more closely allied. To the latter, that we find very varied forms of metamorphosis within the limits of a single order, so that it would require a dismemberment of the orders to uphold the distinction in a logical form.

In the attempts alluded to above, naturalists have simply selected, as it were, combinations of acknowledged ordinal peculiarities in order to form and distinguish their superordinal divisions, and have failed to search deeper into the general structure for more fundamental characteristics. Packard, however, has done this, and by employing the terms Metabola of Leach, in a modified sense, and Heterometabola, has brought the Hymenoptera, Lepidoptera and Diptera under the former, and the other orders under the latter. In a paper published six years ago on the Early Types of Insects, I gave my adhesion to this view, and strengthened it, as I believe, by some additional characteristics drawn from the regional divisions of the trunk. In the Metabola, the thorax, supporting the organs of aerial locomotion—a primary feature of the Hexapoda as a whole—is very highly organized and compact, well differentiated from both head and abdomen, the prothorax very small; the body is generally cylindrical; the mouth parts prolonged into a beak of some sort, and the mandibles rarely opposed at tip; the front wings are membranous and larger, generally very much larger, than the hind pair; the larva is cylindrical and in no way resembles the adult, and the pupa is inactive. In the Heterometabola, on the other hand, the prothorax is large, and the joints of the thorax are less compacted, as a rule, than in the Metabola, or, if compacted, generally massively soldered to the abdomen; the body is usually flattened; the mouth parts are generally not prolonged into a beak, and the tips of the mandibles are generally opposed; the front wings are generally more or less coriaceous or with very numerous and thickened veins, and generally smaller than the hind wings; the larva is usually depressed, often resembles the adult in form (excepting, of course, in the wings), and the pupa may be active or inactive.

The exceptions, in special points, to the above general statements, are not few, especially among the less homogeneous Heterometabola, but if any superordinal division of Hexapoda is to be looked for, it would seem to be on the lines here indicated. The points which are especially disturbing are the opposition of the mandibles in the Hymenoptera, and the appearance of many metabolous characteristics among the Neuroptera properly speaking, a group which is, nevertheless, as a whole, admittedly related most nearly to other heterometabolous orders.

That the Metabola should rank, as a whole, higher than the Heterometabola, can scarcely be disputed: the regional division of the body, the structure of the wings for flight, and especially for strong and directed flight, the complication of the mouth parts, and the universally complete metamorphosis and quiescent pupal state,—are fundamental features, in which the hexapodal type is carried, as a whole, to its highest development. And yet, as we shall see, there are some features in which its members have held to fundamental characteristics of paleozoic hexapods more firmly than have most of the heterometabolous groups.

This brings us fairly to the main object of this paper. What were the relations of the ancient to the modern types of winged insects? In what succession did the two superordinal divisions of insects appear, and at what period the different orders as we now recognize them? What light, in short, can paleontology throw upon the origin and succession of insects?

In attempting some years ago, in a paper already referred to, to answer this question in a broad way, I stated that all the orders of Heterometabola, and none of Metabola, had been found in paleozoic deposits. To-day I shall have to modify this proposition. Not only have numerous discoveries been made in paleozoic deposits within the past six years, but those already known have been subjected to more rigorous study and wider comparisons, which have considerably enlarged our knowledge. Protophasma had then only just been discovered, an insect which has done more than any other, excepting Eugereon, to throw light on the fundamental characteristics of the early world of insects; and even now Brongniart has published but five or six examples of the treasures of Commentry, a place which has already yielded remains exceeding in numbers those of all the rest of the world put together. Nor must we leave out of sight his discovery of a winged insect in the Silurian.

While our knowledge of paleozoic insects is thus shown to be clearly still in its infancy, it may appear hazardous to attempt to formulate statements of a broad and sweeping character concerning the appearance of the primary groups of insects in paleozoic times, especially if I am already compelled within six years to modify such assertions then made. Yet when I point out the nature of this modification, made after a special study of every known paleozoic form, it will appear less hazardous.

The modification I would introduce is to this effect: That while we may recognize in the paleozoic rocks insects which were plainly precursors of existing Heterometabola, viz.: Orthoptera, Neuroptera (both Neuroptera proper and Pseudoneuroptera), Hemiptera (both Homoptera and Heteroptera), and perhaps Coleoptera — and no Metabola whatever — a statement almost identical with that previously made, we may yet not call these Orthoptera, Neuroptera, etc., since *ordinal features were not then differentiated;* but all paleozoic insects belonged to a single order which, enlarging its scope as outlined by Goldenberg, we may call Palaeodictyoptera; in other words, the paleozoic insect was a generalized Hexapod, or more particularly a generalized Heterometabolon. Ordinal differentiation had not begun in paleozoic times.

It will be asked, were there then no cockroaches in paleozoic times? I answer, yes; cockroaches but no Orthoptera; Palaeoblattariae, not Blattariae; that is, Palaeodictyoptera, not Orthoptera. Mayflies; but they were Palephemeridae, not Ephemeridae—again, not Neuroptera but Palaeodictyoptera. Walking sticks; but no Phasmida—only Protophasmida, another group of Palaeodictyoptera.

The grounds for this view are as follows: 1. No group of paleozoic insects has yet been studied carefully—and it is important to observe that, though our knowledge of them is of necessity fragmentary, yet the more perfectly they are known the clearer is this true—no group, I say, has been carefully studied which does not show, between it and the modern group which it most resembles, differences so great that it must be separated from that group as a whole, as one of equal taxonomic rank, as in the case of the three related groups last mentioned.

2. That the different larger groups of paleozoic times, of which we now know nine or ten, were more closely related to one another, at least in the structure of their wings (which is the only point of general structure yet open for comparison), than any one of them is to that modern group to which it is most allied, and of which it was with little

doubt the precursor or ancestral type. Thus the Palaeoblattariae are more nearly allied in the ground structure of their wings to certain neuropteroid Palaeodictyoptera of paleozoic times than to the modern Blattariae: and yet we can so completely trace in mesozoic times the transition from the Palaeoblattariae to the Blattariae, that no reasonable doubt can exist as to their descent, the one from the other.

3. The ordinal distinction which is now found in the wing structure of modern insects did not exist in paleozoic insects, but a common simple type of neuration which barely admitted of family division.

It will appear from this that, by a sort of principle of family continuity, we may recognize in the paleozoic insects a tendency toward a differentiation in ordinal characters, sufficient to enable us in an *ex post facto* fashion to distinguish between orthopteroid, neuropteroid, etc. Palaeodictyoptera.

In speaking above of the different orders of Heterometabola which were foreshadowed in ancient times, I included the Coleoptera with a limitation, for the following reasons: Troxites, the only supposed paleozoic beetle which has not been shown to be an arachnid, is a very obscure object, and is very likely, as Brongniart has suggested, to be merely some fruit. But there have been found wood borings of different kinds which so nearly resemble similar excavations made now by Coleoptera that it is natural, though of course not necessary, to attribute these to them. Yet if Coleoptera, with front wings differentiated as those of to-day existed then, it would be rather anomalous, since all the paleozoic insects we know excepting one, Phthanocoris, which foreshadowed the heteropterous Hemiptera, had fore wings as completely membranous as the hind wings.

It seems to me probable, therefore, though there are no further grounds for it than those just given, coupled with the present relationship of the Coleoptera to other Heterometabola, that Coleoptera sprang from such Palaeodictyoptera as were wood-borers throughout the greater part of their life, and which at first showed no greater distinction between the front and hind wings than existed generally in other Palaeodictyoptera; but afterward those races were preserved in which the thickening of the membrane of the upper wings the better protected the insects while in their burrows for the marriage flight in open air. Their habits would render their preservation in the rocks less frequent, and this special differentiation would be likely to proceed rapidly, and to be retained even by those which lost the wood boring habit;—a habit, by the way, likely to have existed with some insects living in the vast carboniferous forests.

Of the metamorphoses of the paleozoic insects we know absolutely nothing, for no larval or pupal form has yet been found, nor even any apterous insect[1] which might by any possibility be looked upon as such. The preparatory stages of existing Heterometabola; the fact that from every form of evidence the more "complete" metamorphosis must have been derived from the less complete; and the generally admitted proposition of Brauer and others that metamorphosis, that is, radical change of form after birth, is a secondary adaptive feature;—these all lead us to conclude that the only significant change in the paleozoic Palaeodictyopteron after leaving the egg was the acquirement of wings; and that the acquirement of wings was the lever which natural selection handled to procure the present varied forms of metamorphosis in insects.

[1] Polyzosterites of Goldenberg is looked upon as a crustacean.

A curious and somewhat unexpected fact is found in the present universal prevalence of membranous front wings in all the orders of Metabola, similar to what is found in the direct paleozoic ancestors of Heterometabola; while most existing Heterometabola, though lower in general organization than the Metabola, have passed beyond this feature of uniformity to one of greater differentiation, the front wings being more or less coriaceous, while the hind wings are still membranous. This, together with the direct relation of some paleozoic insects to later types, would lead us to believe that we are to look at the neuropteroid Palaeodictyoptera as the ancestors not only of later Neuroptera but also of all Metabola, and would account in a measure for the somewhat close relationship of the Phryganidae and lower Lepidoptera.[1]

Allusion has been made to Brongniart's discovery of an insect's wing in the middle Silurian—a long way removed from the upper Devonian, which had hitherto been their lowest known horizon. But though he quickly published a rude figure of his fossil, it is insufficient for critical purposes, and it would probably be hard to obtain from a single discovery the clew we need as to the ancestry of the Palaeodictyoptera. We may safely conclude, however, that the winged Palaeodictyoptera came in as early as the middle Silurian and that up to the close of the paleozoic epoch their divergent stems were still admissible into one general order.

Now when we look at the insects of later formations, we find types of every one of the existing orders of insects—speaking of these orders in their broadest sense, as we have everywhere done in this essay — we find every one fully developed in the Jurassic period.

In the Orthoptera we find as good a proof as anywhere, since cockroaches are the only insects found in any numbers in the very lowest mesozoic rocks. Their presence in the Trias and its significance will be alluded to later. In the Jurassic rocks nearly forty species are known, of which about one-third are in the lower Jurassic, and nearly all are true Blattariae. So too in the Liassic rocks we recognize all the families of saltatorial Orthoptera and the Forficulariae, so that the Orthoptera may be considered as well established early in mesozoic times. Unfortunately no Phasmida have yet been recovered.

Only one or two Neuroptera have been recognized in the Trias, but in the Lias we have a considerable number, including Megaloptera, Sialina, Panorpidae, Phryganidae, Ephemeridae, Termitina and Odonata, showing that the differentiation into the non-existing families was apparently complete early in mesozoic times, and that forms of nearly all recognized families were abundant in the middle and later Oolite.

The two orders just mentioned are almost the only ones that have yet been recognized in the scanty fauna of the Trias, but the moment we reach the lower Jurassic rocks we find traces of nearly all the others; thus several families both of Homoptera, and of Heteroptera are found in Liassic rocks, including such diverse types as the Coreidae, Belostomidae, Cicadina and Cicadellina, while Fulgorina and Aphidina are added in the Oolite.

The Coleoptera, of which we found only indefinite traces in paleozoic rocks, have been found in the Trias (Chrysomelites), and the adjacent Rhaetic has disclosed forms as different as Hydrophilites, Buprestites and Curculionites, while the Lias already claims some one hundred and twenty-five species referred to as many as seventeen distinct families.

[1] In this connection it would be well to call attention to one of Dr. A. S. Packard's early papers on Neuroptera as a "synthetic type." See Bost. Journ. Nat. Hist., VII, 590.

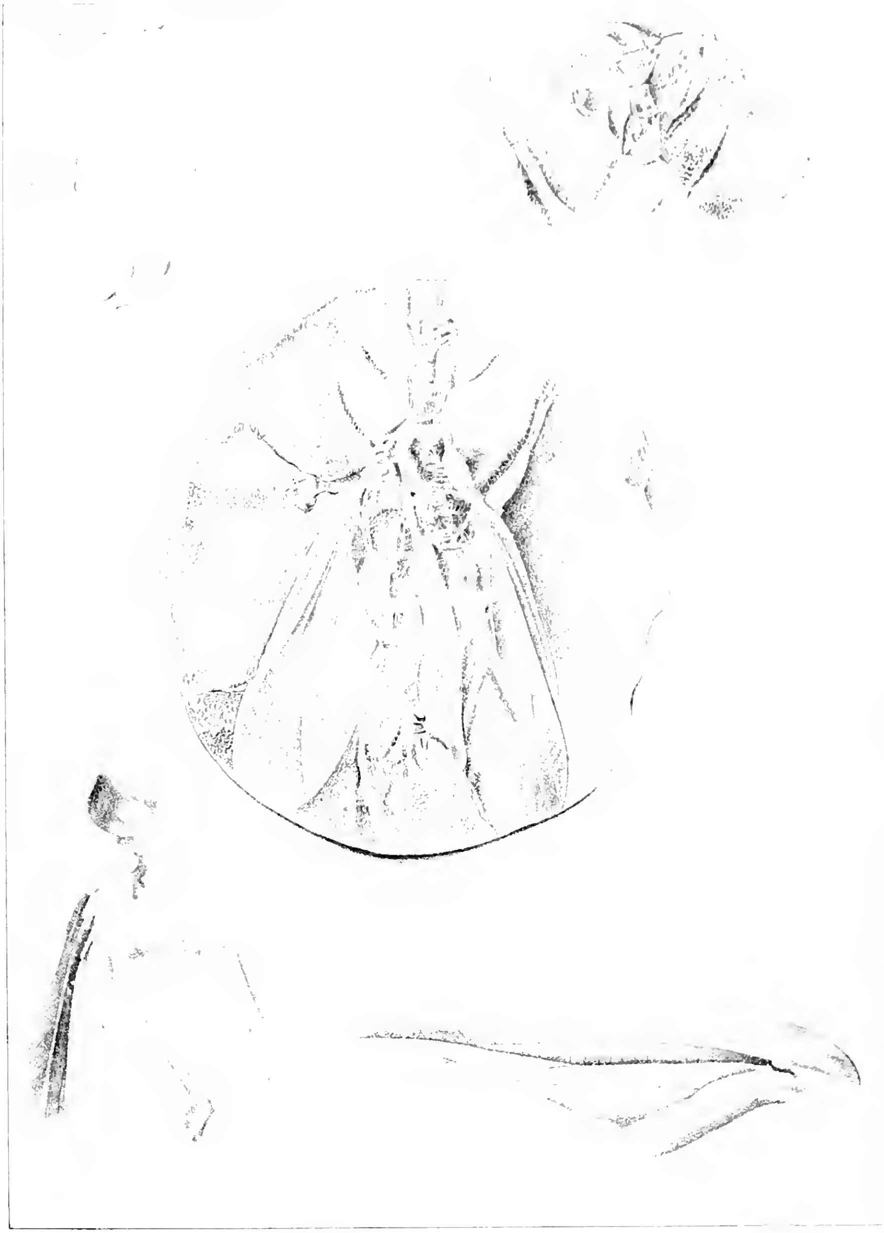
When we come to the metabolous orders we find a scantier representation, but in the more limited sense necessarily attendant upon this fact nearly the same things are true. Three or four species of Diptera, referred to Chironomidae, Tipulidae, and Asilidae, are found as low down as the Lias, about as many more in the middle Oolite, and some fifteen or twenty in the upper Oolite, of several different families, mostly Nemocera. Of Lepidoptera, the remains of which are exceedingly scanty even in the tertiaries, we know of two unquestionable Sphingidae in the middle Oolite, and the mines of a tineid moth in the Cretaceous. While of Hymenoptera we have eight or ten mesozoic species, the oldest of which is an undoubted ant from the Lias, next a wood wasp and four or five very obscure remains from the middle Oolite of Solenhofen, two ants again from the upper Oolite (Purbecks), and the eggs of one of the Tenthredinidae from the Cretaceous.

We find then that the entire change from the generalized hexapod to the ordinally specialized hexapod was made in the interval between the close of the paleozoic period and the middle, we may say, of the mesozoic. These significant changes were ushered in with the dawn of the mesozoic period, and the Triassic rocks become naturally (together with the Silurian) the most important, the expectant, ground of the student of palentomology. Hitherto for fifty years the Carboniferous period has claimed this interest as its birthright.

The Silurian period has furnished only a single insect, just discovered and already alluded to. The Triassic has four or five representatives in the Old World, while a new locality recently made known in Colorado has yielded a considerable number of specimens of about twenty species, mostly still unpublished. Most of these are cockroaches, and they illustrate and enforce the conclusion we have reached in an interesting way. One of them, the European Legnophora of Heer, shows for the first time in the history of cockroaches[1] a thickening of the front wings, rendering the veins nearly obsolete, a characteristic of Blattariae (not always very striking) but never found in Palaeoblattariae. A similar appearance is to be seen in a few of the American cockroaches of the Trias, and in addition to this they are divided between Blattariae and Palaeoblattariae, and the passage from one to the other is traceable. The two exist side by side, but some of the Blattariae have the front wings equally membranous.

It would then appear that the geological history of winged insects, so far as we know from present indications, may be summed up in a very few words. Appearing in the Silurian period, insects continued throughout paleozoic times as a generalized form of Heterometabola which for convenience we have called Palaeodictyoptera, and which had the front wings as well as the hind wings membranous. On the advent of mesozoic times a great differentiation took place, and before its middle all of the orders, both of Heterometabola and of Metabola, were fully developed in all their essential features as they exist to-day, the more highly organized Metabola at first in feeble numbers, but to-day and even in Tertiary times as the prevailing types. The Metabola have from the first retained the membranous character of the front wings, while in most of the Heterometabola, which were more closely and directly connected with paleozoic types, the front wings were, even in mesozoic times, more or less completely differentiated from the hind wings, as a sort of protective covering to the latter, and these became the principal organs of flight.

[1] Etoblattina insignis Goldenb., sp., may, perhaps, be an exception, but the apparent thickening may be due to poor preservation, as the hind wings share fully the same characteristic. Is it possibly a "pupal" form?



XIV. The Life-History of the Hydromedusæ: A Discussion of the Origin of the Medusæ, and of the Significance of Metagenesis.

By W. K. Brooks, Johns Hopkins University, Baltimore, Md.

(Read Oct. 7, 1885.)

Most recent writers upon the origin of the sexual Medusae which are set free from communities of sessile hydroids, and upon the relation between them and the hydroids, agree in the opinion that the sessile community is the primitive form from which the medusae have been derived, and that the medusae have originated through the gradual specialization of the reproductive members of a polymorphic hydroid-cormus.

This opinion is generally, but not universally, accepted for Böhm (9) has given his reasons for believing that the medusae have arisen from floating, rather than fixed hydroids; and Claus has advanced the opinion that the medusa is older than the polymorphic hydroid-cormus, that the hydra is simply a medusa-larva, and that the alternation of generations has originated through the power to multiply asexually which this larva possesses; and that the alternation of generations is therefore a secondary modification of a life-history which was originally simple and direct.

Neither of these writers refers to the life-history of the Narcomedusæ and Trachomedusæ, and the purpose of the present paper is to show that the metamorphosis of these medusæ furnishes direct disproof of the polymorphism-hypothesis, and completely establishes the explanation advanced by Böhm and Claus, through evidence which neither of these authors discusses.

I may also be allowed to state that I was led, several years ago, by the study of the development of the Trachomedusæ and Narcomedusæ, to the conclusions which are here given, before I was aware that Böhm and Claus had also arrived at the same view of the relation between the medusa and the hydra. As this is my first opportunity to publish the illustrations which are necessary for demonstrating the correctness of this conclusion, I now select, from notes which I have made on the Medusæ of Beaufort during the past six years at the Marine Laboratory of the Johns Hopkins University, those observations which are best adapted for illustrating my view of the origin and significance of alternation of generations or metagenesis in the Hydromedusæ. This paper therefore contains an account of the life-history of a Narcomedusa, *Cunocantha* *octonaria;* a Trachomedusa, *Liriope scutigera;* an Anthomedusa, *Turritopsis nutricula;* and a Leptomedusa, *Eutima mira.* I give detailed accounts of these four life-histories, as I believe that in each case I have enough new facts to warrant their publication as purely descriptive work, independently of their usefulness as illustrations.

I take this opportunity to express my indebtedness to Messrs. A. Hoen & Co. of Baltimore; who, prompted by their interest in the advancement of science, have warmly seconded my efforts to obtain satisfactory photo-lithographs from pen drawings, and have permitted me to draw at will upon their technical knowledge, and upon the resources of their establishment.

The four species which I have selected are among the most abundant and characteristic medusæ of our southern coast, and as no figures of the adult *Cunocantha octonaria,* or *Liriope scutigera* have ever been published, and as nothing whatever has ever been known of the life-history of Turritopsis or Eutima, I have made use of the opportunities which have been afforded by a residence of several summers on our southern coast to obtain a thorough knowledge of these common species.

In a recent paper (1), A. Agassiz says that "Haeckel's work shows how much progress could be made in our knowledge of Acalephs by selecting a few properly placed stations where Medusæ could be studied advantageously," and I hope that this paper will also serve to exhibit the value of such stations.

The four species which I have studied have all been accurately described by McCrady (48), but as my daily familiarity with them for several seasons has enabled me to add many new points, and to correct the few errors which occur in his writings, it seems best to preface my account of the development by a brief revision of the systematic zoology of each species. This is the more necessary as an unfortunate accident destroyed nearly the whole edition of McCrady's papers soon after they were printed, and they are now almost unattainable by the student; and while his descriptions are very graphic, later writers have often given his specific names to other Medusæ than those which he studied.

Section I. The Narcomedusæ.

Plates 43, 44.

Although Cunina and its allies have, in times past, been regarded as Discophoræ rather than Hydromedusæ, chiefly on the account of the fact that the gelatinous substance of the bell is lobed, and also on account of the very striking resemblance between a Cunina and an Ephyra, I think that naturalists are now almost universally disposed to agree that these resemblances are superficial and that the Cuninas and Æginas are true veiled Medusæ. The establishment of a correct view of their affinities is due in great part to the careful study of their anatomical structure, which Haeckel was led to undertake on account of his remarkable hypothesis that they are genetically related to the Geryonidæ, and that the two forms are stages in the same life-cycle; and we can well afford to overlook this error since its fortunate result has been a clearer insight into the affinities of the most instructive of all the Hydromedusæ. His conclusions regarding their relationship to the Craspedotæ are so generally received that it is unnecessary to discuss the subject, nor do I believe that any one doubts the propriety of establishing for these forms a distinct order of Hydromedusæ. Cunina then is a representative of Haeckel's fourth order of Hydromedusæ, the Narcomedusæ, or veiled medusæ with free tentacular auditory organs, with endodermal otolith cells on the bell margin; with ocelli usually absent, and the tentacles inserted on the dorsal surface of the umbrella, and connected by peronia with the free edge, which is thus divided into a number of lobes. Radial canals absent, or present as flat radial stomach pockets, in the sub-umbral walls of which the reproductive elements are developed. Circular canal obliterated or converted into a series of festoon canals, which fringe the edges of the lobes. The number of radial organs is very variable, seldom four, usually eight, and often as many as thirty-two. Velum thin and wide. Ontogeny, so far as observed, a metamorphosis, with metagenesis in a few exceptional forms. Cunina belongs to the first of Haeckel's four families, the *Cunanthidæ*, or Narcomedusæ with broad, radial stomach-pockets, which are united to the circular canal by double peronial canals; with otoporpæ or ciliated centripetal stripes, and with nettle cells at the bases of the auditory tentacles. Our species, *Cunina octonaria*, McCrady, belongs to Haeckel's genus Cunocantha, which includes species with only eight tentacles, while the true Cuninas have more than eight; and these eight tentacles are inserted into the ends of the eight stomach pockets, while Cunoctina, which also has eight tentacles, has them inserted into deep notches which divide each pocket into two.

Cunocantha octonaria, *Haeckel.*

Plates 43 and 44.

Cunina octonaria, McCrady, 1857. Gymnophthalmata of Charleston Harbor, p. 109, pl. 12, fig. 4 (young specimen).
Foveolia octonaria, A. Agassiz, 1865. N. A. Acalephæ, p. 57.
Cunocantha octonaria, Haeckel, 1879. Das System der Medusen, p. 316.

Species-Diagnosis. Umbrella lens-shaped, more than twice as wide as high. The eight lobes semicircular, and about two-thirds as long as radius of central portion of umbrella. Stomach pendent, reaching nearly to level of veil, with a wide base and a small circular contractile mouth. Stomach pockets a little wider at distal than at proximal ends, with reproductive elements developed over the whole sub-umbral surface, two-thirds as long as the radius of central portion of umbrella. The tips of the eight equal tentacles project only a little beyond the bell margin. Three auditory tentacles on each of the eight lobes, the central one largest.

Color. Stomach pockets and tentacles golden brown.

Size. Diameter 12 mm. Height, 5 mm.

Ontogeny. Metamorphosis together with asexual multiplication of the larvæ, which are parasitic in the bell cavity of Turritopsis.

Habitat. Charleston, S. C., McCrady; Beaufort, N. C., Brooks; Hampton Roads, Virginia, Brooks.

While the larvæ are said by McCrady to be quite common at Charleston, he found no mature specimens, and only one which had the adult characteristics. He figures this specimen in his Pl. 12, fig. 1, and this figure is copied as fig. 3 of Pl. 44, of this paper. The figures of the adult which are here given, Pl. 44, figs. 4 and 5, are the only ones which have ever been published. Adult specimens are quite common at Beaufort during September and October, but I have found very few during the last weeks of August, or earlier, nor do the specimens of Turritopsis which are captured early in August contain the larvæ, although these are present in about one-third of the specimens which are captured after the Cuninas make their appearance.

By actually rearing the larvæ and medusæ, I have verified McCrady's conjecture that the parasitic form found in the bell of Turritopsis is the young of this species; and while there was no reason to doubt this conclusion, the extremely great interest of the subject, and the very perplexing character of most of our information regarding the parasitic Cuninas, rendered this direct proof very desirable.

One other species of Cunina, *C. discoides*, Fewkes (21), is a very rare visitor at Beaufort, and I have found only a single immature specimen, which was captured outside the bar on Sept. 2, 1882.

The Life-History of Cunocantha octonaria.

The Narcomedusæ are unquestionably the most primitive of the Hydromedusæ, and we might therefore expect their ontogenetic development to throw light upon the more complicated life-histories of the other members of the group, and I shall try to show that this actually is the case, and that the series of species which have been carefully studied does present us with the successive steps through which metamorphosis has become converted into metagenesis or alternation of generations. Our species furnishes one very important link in this chain, and as I have been able to verify all the points in McCrady's classic, but almost inaccessible paper, and to add many new ones, I shall give as complete an account as possible of the metamorphosis, using my own material as well as McCrady's description.

The life-history is illustrated by Plates 43 and 44. Figs. 2 and 5 of Pl. 43, and figs. 3 and 6 of Pl. 44, are copied from McCrady, while the others are original drawings from nature.

McCrady gives (19, p. 10) the following account of the discovery of the larvæ. "In the early part of July, I found the first full-grown specimens of Turritopsis. Among them was one somewhat larger, perhaps, than the rest, which I took with the bell inverted. When placed under the microscope, conceive my astonishment to find, clinging to the bell and sides of the proboscis, numerous little animals of singular aspect, each of which appeared to be sustaining his hold by a four-legged pedestal, and to be writhing about in the water a long appendage, the meaning of which I could not understand. * * * It was not until the 15th of August, that I again encountered the same phenomenon, in a smaller size of Turritopsis, of which quite a number were taken. I found the cavity of the bell around the proboscis again occupied by these larvæ" (see Pl. 44, fig. 6, which is copied from McCrady's Pl. 5, fig. 28), "but besides these formerly observed, were others, which were gradually becoming Medusæ, and still others which had assumed the Medusa-form already, and, lastly, to complete my satisfaction, I saw them, after expulsion from their former abode, swimming about freely in the water, with the rhythmical contractions of Medusæ. It was quite plain from this, that expulsion had taken place, but still I had not seen the expelled animals until some time after the occurrence, and it was not until a later date, Sept. 18th, that I had an opportunity of observing the condition of the larva at the time of expulsion. From this I learned that shortly after assuming independence the larva changes the Medusa-form, under which it is first freed, for another which is more persistent."

Although McCrady believed, at the time his first paper was written, that the larvæ were the young of Turritopsis, he discovered that their position inside the bell is not their primitive one, and the youngest larvæ which he found, and of which he gives the following description, were on the bell-margin among the tentacles. He says of this stage, "It was proboscidian and apparently unprovided with tentacles. * * * It was clinging to the tentaculiferous border of the parents' disk, by means of the extremity of its own proboscis. This circumstance also was peculiar, since in no other instance have I seen the larva to use the proboscis as even a means of temporary adherence for the purpose of locomotion. Its position, also, at the border of the disk, is worthy of especial notice, for the habitual position of the tentaculated larva, is on the sides of the proboscis of the parent, or clinging to the inner surface of the upper part of the swim-bell, and in no other instance have I been able to satisfy myself that there was any adhesion to the tentaculiferous border. Just within the cavity, and almost on the border of the veil, it clung with such tenacity that, notwithstanding the powerful contractions of the parent, by which it would be thrown, now within and now without the opening of the swim-bell, its hold was never lost. Yet it appeared to be in contracted condition from the constant irritation to which, by its position, it was subjected. From the same cause I was prevented from making anything but an outline." This rough outline seems to show that this larva was like, or perhaps a little younger than, the one shown in Pl. 43, fig. 1.

This also was found on the bell-margin, and consisted of a body with two short stout tentacles, ending in rounded batteries of lasso cells, and a very long proboscis with a very small mouth. The digestive cavity, *e*, is lined by large ciliated endoderm cells, *f*, and the mouth may be closed until it is almost invisible, or it may be widely opened. The ectoderm, which contains scattered lasso cells and spots of brown pigment, is thin everywhere, except at the tips of the tentacles and at the aboral end, between the bases of the tentacles, where it forms a thickened pad, *g*.

When detached it swims or glides slowly through the water, and as floating particles are driven away from the surface, there can be no doubt that the ectoderm is covered with small cilia, although I was not able to see them. McCrady says that his specimens had no mouth or tentacles, but his figures show that the larva was essentially like the one which I have drawn, although the tentacles may possibly have been a little shorter.

The very close similarity between this larva and the larva of Polyxenia which Metschnikoff has studied (51), renders it probable that the egg in this case also gives rise to a ciliated planula which floats in the water, and acquires a stomach and a mouth, and that two opposite tentacles are then developed, either just before or just after it fixes itself to the Turritopsis. The rhizopod-like stage, which Metschnikoff (52) has described in the parasitic Cunina-larva which is found on Carmarina, is probably absent in our species, and the planula undoubtedly becomes directly converted into the larva shown in fig. 1.

The larva next makes its way into the bell cavity where it fastens itself by the tips of the tentacles, as shown in Pl. 44, fig. 6. Its proboscis now becomes enormously lengthened, as shown in Pl. 44, fig. 1, and its enlarged tip is inserted into the mouth of the Turritopsis, while two new tentacles are developed between the first two, and soon become equal to them in length, and the aboral end of the body becomes a little elongated, between the bases of the tentacles, as shown in fig. 1.

The interesting fact that the larva shown in Pl. 44, fig. 1, is a true hydra, differing from the actinula larva of Tubularia only in the length of its proboscis and the small number of tentacles, has been almost completely overlooked by all recent writers, although it did not escape McCrady's attention. He says in his second paper, in his diagnosis of the genus Cunina (18, p. 108), "Larva a free hydra, like the free stage of the Tubularia," and on p. 12 of his first paper (19), "The resemblance of these beings to the free young hydra of Tubularia was unmistakable." Very soon after the larva fastens itself by its tentacles, and either before or soon after the two secondary tentacles are developed, it begins to multiply asexually by budding from the aboral process between the bases of the tentacles, and thus forms little communities, like the one shown in Pl. 43, fig. 2, which is copied from McCrady, who calls attention on p. 21, to the obvious fact that this method of budding from an area which is aboral to the tentacles is directly comparable with what occurs in the fixed hydroids, when this part of the body becomes the stem or root. On p. 14, he states his belief that no more than two buds are ever developed at one time, but this is an error, as communities like the one shown in fig. 3, consisting of six or seven larvæ, are frequently met with. This figure will also serve to illustrate the changes through which the larva passes during its development and conversion into the medusa. The young buds have, at first, no tentacles and no mouth, but the proboscis soon lengthens, the mouth appears at its tip, and two opposite tentacles grow out from its base, and are soon followed by two more, alternating with, and at first shorter than the primary tentacles. A rim or flange now grows out from the wall of the body, and in the zone which is occupied by the bases of the tentacles. This zone which is to become the umbrella of the medusa occupies the same position as the inter-tentacular web of such hydroids as the Campanopsis-larva of Eutima, although, unlike the inter-tentacular web, it is composed of both layers of the body wall, and contains a circular diverticulum from the digestive cavity. Four more tentacles now make their appearance, alternating with the first four, and the circular rim becomes notched or infolded opposite the base of each tentacle, or more strictly the free edge between the tentacles grows faster than it does elsewhere, and thus converts the rim into eight marginal lobes, each of which contains a pocket or diverticulum from the central digestive cavity. The tentacles are at first on the rim, in the notches between the lobes, but they very soon begin their migration towards the aboral pole of the body. It is important to note that the lobes are at first directly comparable to the marginal lobes of an Ephyra, inasmuch as their free edges are entirely separated from each other. As the tentacles retreat however, and the notches deepen, the endoderm alone is infolded, thus leaving the bottom of each notch spanned over by a double layer of ectoderm, the radial string of the adult. A sensory tentacle, with a single otolith now grows out from the tip of each lobe, and the free edges of the lobes bend down towards the mouth, thus forming a shallow circular sub-umbrella around the base of the proboscis, and at this stage the larva detaches itself and escapes into the water as a medusa, fig. 4, with an enormously long proboscis, a shallow sub-umbrella, four long and four short tentacles, and alternating with the tentacles, eight marginal lobes, each of which ends in an auditory tentacle, and contains a spacious diverticulum from the central stomach. I have not been able to study the manner in which this cavity becomes converted into the "festoon-canal," but this is probably formed by the growth of an area of adhesion in the centre of each lobe, between the sub-umbral and the ex-umbral endoderm. The pockets of the young medusæ shown in Pl. 13, fig. 4, must not be compared with those of the adult Cunina which are of much later origin. After the medusa is set free the umbrella grows very rapidly, while the proboscis remains without change, so that the animal soon assumes the form shown in Pl. 13, fig. 5, which is an aboral view, copied from McCrady. The lateral pockets of the digestive cavity have now disappeared and the central digestive cavity is nearly circular, but it soon becomes folded in at its edge, between the bases of the tentacles, as shown in Pl. 14, fig. 2, in which figure the right half is an oral, and the left an aboral view. The eight inter-tentacular notches on the free edge of the stomach now deepen rapidly as shown in fig. 3 (copied from McCrady), and thus give rise to the eight stomach pockets of the adult, while a thickening on the oral surface around the circumference of the stomach marks the rudimentary reproductive organs, which soon spread over the whole oral surface of the pockets. The long proboscis of the larva soon disappears, so that the stomach becomes a flat pouch with a contractile mouth in its centre, but in the adult the oral wall of the stomach again becomes drawn downwards to form a pendent proboscis.

The life-history of *Cunocantha octonaria* may now be briefly summarized as follows:

The larva is a ciliated swimming organism, with a mouth, a long proboscis and two opposite tentacles. It soon develops two more tentacles, loses its cilia, and becomes a hydra with a greatly developed proboscis and with its aboral extremity reduced to a small prominence, from which other hydras are budded. There is no sessile stage, but the locomotor hydra makes its way into the bell of a Turritopsis, where it fastens itself by its tentacles, and lives as a parasite. It then becomes directly converted into a medusa by the outgrowth of an umbrella around its tentacular zone, and escaping into the water begins its medusan life. Before it becomes a medusa it produces other larvæ by budding, and all these become medusæ. The state of our knowledge of the development of other Narcomedusæ, especially of Polyxenia and Æginopsis, indicates that the parasitic habit of the larvæ is not primitive but recently acquired, and the tendency to multiply asexually has probably been also secondarily acquired by the larva as an adaptation to its parasitic life. In the case of our Cunocantha all the larvæ become medusæ, and there is therefore no true alternation of generations, but in the case of the Cunina studied by Uljanin (60), and afterwards by Metschnikoff, the adaptation to a parasitic habit is much more perfect, and the larva which hatches from the egg and gains access to the Carmarina, never becomes converted into a perfect medusa, but remains as a degraded nurse, from which other larva are budded, and as Uljanin points out, we have in this case a true alternation of generations.

THE EVOLUTION OF OUR KNOWLEDGE OF THE LIFE-HISTORY OF THE NARCOMEDUSÆ.

The growth of our knowledge of the Narcomedusæ forms one of the most remarkable chapters in the history of zoology, and I shall review it at some length, in order to exhibit the life-history of our American *Cunina octonaria* in its true relations, and also to show by what slight increments our knowledge has grown. The life of an animal which passes part of its time inside the body of another as a parasite, and then, assuming quite a different form swims at large in the water, presents a very perplexing puzzle, which becomes still more confusing when, as in the Narcomedusæ, some species are parasitic and others are not. Each observation then becomes important, and I shall refer to many papers which contain very small additions to our positive knowledge, the present state of which may be summarized as follows:

1. Some of the Narcomedusæ develop directly from the egg, without asexual multiplication.

2. In other species the ciliated larva becomes a parasite upon the body of a totally different medusa, gaining access to the sub-umbrella of Turritopsis, or to the digestive cavity of a Geryonid. It there multiplies asexually; producing, by budding from an aboral stolon, other larvæ which are at first hydras. These hydra larvæ become converted into medusæ by direct metamorphosis.

3. Similar Cunina larvæ are found in the stomachs of many species of Cunina. In some cases the larvæ become converted into Cuninas with the specific characteristics of the adult which carries them, but in other cases they differ in the number of tentacles and sense organs, and in other particulars. The youngest of these larvæ are free and ciliated, while the older ones are attached and produce buds from an aboral stolon.

4. No one has shown, by careful examination, that any adult Cunina produces buds from its stomach or from any other part of its body, and there is every reason for believing that the Cunina larvæ found in their stomachs are parasites, like those found in Turritopsis and in Geryonids, and that a Cunina larva, found in the stomach of an adult Cunina, does not necessarily belong to the same species with the adult.

So far as I am aware Krohn was the first to observe a Cunina larva. In a paper which was published in 1861 (41), he says that he found at Messina, in 1843, great numbers of tentaculated larvæ, fastened by their aboral surfaces to the protruded gastrostyle of a Geryonid, *Geryonia proboscidalis*. He gives few details, and appears to regard the larvæ as the asexual progeny of the Geryonia.

In 1851, Johannes Müller (71) captured at the surface of the ocean at Marseilles great numbers of small ciliated larvæ, and a series of older stages which were sufficiently complete to satisfy him that the larva is the young of a very simply organized Narcomedusa, *Æginopsis (Solmundella) mediterranea*.

As the youngest larvæ are ciliated, he believed that they are newly-hatched egg-embryos, and as each one of them becomes converted into a medusa, he suggests that

Æginopsis will probably be found to develop directly from the egg without alternation: a prophecy which was verified twenty-five years later by Metschnikoff (51).

The youngest larva which Muller figures, Pl. xi, fig. 1, is a hydra essentially like the one shown in our Pl. 13, fig. 1. The position of the tentacles is different, but he says in the text, that they are often carried as they are shown in our figure.

In the autumn of the following year, 1852, three young naturalists, Gegenbaur, Kolliker and H. Müller, met at Messina to spend a few months in zoological research at the seashore, and their fruitful harvest furnishes one with the earliest evidences of the value of marine zoological stations.

Kölliker, who studied the lower invertebrates, made many interesting observations on the medusæ, one of the most important being the discovery of young Cuninas in the stomach of an old one, which he names *Eurystoma rubiginosum* (*Cunina rubiginosa*, Haeck.).

The oldest larvæ are so similar to another Cunina which he found at the same place, and named *Stenogaster complanatus*, that he decided that they were the young of this species. He says nothing about budding from the stomach, and adopts the view, which is undoubtedly correct, that they had gained access to the stomach from outside, although he supposes that they had been swallowed by the Eurystoma as food.

In 1854, Gegenbaur (21) found small bud-like bodies, each with four tentacles, attached to the walls of the stomach of a Cunina, which he named *Cunina prolifera*, since he supposed, from the fact that the larvæ became adults of the same species, that they are produced by budding.

The observations which come next in historical order (1856) are by an American naturalist, McCrady (18, 49), and they will always remain a monument to the accuracy of this sharp-sighted observer, for they give for the first time a pretty complete history of the life of a Cunina, which is accurately illustrated and vividly described. McCrady's papers are very different from the brief notices which have been referred to above, and they are by far the most important which have ever appeared upon the subject. They not only serve to throw a flood of light upon the significance of earlier observations, but they also contain a record of facts which should have prevented the confusion which later writers have introduced. Unfortunately the edition of his paper was almost completely destroyed before it was distributed, and reference to it is now nearly impossible, and although proper credit is now given to the author, a desire to place the facts which it contains within the reach of all was as strong an inducement to the preparation of this paper as my desire to publish my own additions to the subject. I have illustrated some stages which he did not obtain, and my figures exhibit many points which are not shown in his much smaller ones, but I have also copied a few of his original figures, and I have embodied all the leading points of his paper, the chief results of which are as follows:

1. The young *Cunina octonaria* is a parasite inside the bell of a Hydromedusa, Turritopsis.

2. The larva is a hydra.

3. It multiplies asexually by budding from an aboral stolon, and gives rise to other larvæ like itself.

4. Each larva finally becomes metamorphosed into a medusa, and there is no alternation of generations.

McCrady's papers were published in 1856 and 1857, and at about the same time (1856) Leuckart (47) figured and described a Cunina larva under the name *Pyxidium truncatum* (Pl. 11, fig. 7), but he gives no account of its history.

In 1860, Keferstein and Ehlers (72) repeated Gegenbaur's observations upon a Cunina which they call *Ægineta gemmifera*, but which is probably the same as *Ægineta (Cunina) prolifera*, Gegenb. They were ignorant of McCrady's work, and believed with Gegenbaur that the larvæ are formed as buds from the wall of the stomach.

In 1861, Krohn published the observation above referred to, made in 1843, to the effect that peculiar bud-like bodies are sometimes found on the gastrostyle of Geryonids, and the same volume of the Archiv f. Naturgeschichte contained a paper by Fritz Müller (56), in which he says that, in 1860, he found on the gastrostyle of a Brazilian Geryonid, *Liriope catherinensis*, a group of medusa-buds, each of which became metamorphosed into a young Cunina closely resembling an adult Brazilian Cunina which he names *Cunina Köllikeri*. In the same paper he says that in 1859 he found in the stomachs of male specimens of the Cunina, young ciliated larvæ which became young Cuninas, differing from *C. Köllikeri*, in the number of tentacles. He holds that the larvæ found in the stomach of the adult Cunina are asexual buds from the walls of the stomach, while he believes that those found in the stomach of the Geryonid have been swallowed as food.

In 1865, Noschin published a paper (57), in which he states that he has found on the gastrostyle of *Geryonia (Carmarina) hastata*, bud-like larvæ which became medusæ which he identifies as young specimens of Keferstein and Ehlers' *Cunina discoidalis.* He regards this as a case of alternation of generations, and advances the astonishing hypothesis that the Geryonid, a Trachomedusa, and Cunina, a Narcomedusa, belong to the same cycle, and that the buds which become Cuninas are produced by the Carmarina.

In the same year Haeckel published a brief preliminary abstract and two fully illustrated papers (29, 30), in which he describes the same facts, and advances, independently, the same astonishing hypothesis, but the mistake is the more remarkable in this case since Haeckel had himself traced the metamorphosis of Carmarina from a very young and small larval medusa, which, as he correctly conjectures, is an egg-embryo (30 *d*). If we believe that the Cunina buds are also produced by the Carmarina, we are compelled to believe that this medusa has two methods of reproduction, producing Geryonids like itself from eggs, and producing Cuninas from internal buds. Haeckel boldly accepts this hypothesis (30 *a*, p. 181), and says on p. 293, "I do not doubt that what I have here described as a remarkable exception will in time be found to be a widely distributed occurrence, at least among the lower medusæ, especially the Æginidæ. Allotriogenesis or allocogenesis, as this form of reproduction may be called, is very essentially different from all forms of alternation of generations." Haeckel's papers are beautifully illustrated, and his figures show that although the proboscis of his larva is shorter than that of *Cunina octonaria*, and the number of buds which are produced very much greater, there is, in all other respects the closest resemblance to the American larva as described by McCrady, with whose work Haeckel was not acquainted.

On the whole Haeckel's error was a fortunate one for science, for it led him to make a very thorough comparative study of the adult Geryonid and Cunina, and this comparison resulted in his two valuable and beautifully illustrated papers (30), and showed conclusively that the Cuninas are veiled medusæ, not very different in structure from the Geryonidæ, through which they are related to the ordinary Hydromedusæ. The Cuninas and their allies had previously been regarded as Acraspeda, but Haeckel's results, which are now almost universally accepted, form a valuable addition to positive science, although they were based upon this strange hypothesis.

The next paper in historical order contains no new observations, and is simply an attempt by Allman (6) to bring Haeckel's hypothesis into harmony with our knowledge of other hydroids. He accepts without question Haeckel's opinion that a Geryonid may give rise to Cuninas by budding, and he sees nothing remarkable in such an occurrence. On p. 469, he says "While the observations of Haeckel, however, can scarcely be too highly estimated for the light they throw upon the relation between the Geryonidæ and Æginidæ, it appears to me that he *greatly overrates* the difference between the genetic phenomena which are here presented and those already well known among the Hydroida." He then gives a series of diagrams by the aid of which he attempts to show that the production of medusæ by budding from the wall of the stomach of a medusa of a totally distinct order, which also reproduces itself normally by eggs, is no more than the analogy of Hydractinia would lead us to expect. He makes no reference to McCrady's paper, with which he does not seem to be acquainted. It is rather strange to find that while he accepts without question the statement that a Geryonid may produce Cuninas by budding, he is half disposed to believe that the Cunina buds found in Cuninas by Gegenbaur, Keferstein and Fritz Müller, are to be regarded as "suggesting parasitism rather than gemmation" (p. 471).

Metschnikoff's papers (30 *a*, *b*, and *c*), which come next in historical order (1871), are, with the exception of McCrady's papers, the most important ones which have appeared, for he gives for the first time a complete life-history of two Cuninas, *Ægineta* (*Solmoneta*) *flavescens*, and *Æginopsis* (*Solmundella*) *mediterranea*. He proves, by rearing these medusæ from the egg, the correctness of the prophecy Johannes Müller made twenty-five years before, that, in these two species at least, there is no alternation of generations, no sessile hydra-stage, and no asexual multiplication. In a third paper (30 *a*), he shows, as Fol had done a few months before, that *Geryonia* (*Carmarina*) *hastata* also develops directly from the egg without alternation or budding. In a third paper (30 *c*), he gives an illustrated account of the development of the Cunina larvæ which are found in the stomach of Cunina, and although he calls attention to the close similarity between the youngest of these larvæ and those which he reared from the eggs of Ægineta and Æginopsis, and although the youngest larvæ were found swimming in the stomach, not fastened to its walls, he regards them as buds from the wall of the stomach. His account shows that the history of the larva is very much like that of the one which McCrady studied; that the larva is a hydra; that it multiplies by budding from an aboral stolon, and that the hydra-larvæ which are thus produced change into medusæ by metamorphosis. He does not refer to McCrady, but it seems strange that he was not led to question the origin of the larvæ by budding from the stomach, by his knowledge of the fact that Fritz Müller and Haeckel had observed similar proliferating Cunina larvæ in the stomachs of Geryonids.

In 1875, Uljanin (60, 61) proved that there is no genetic connection between the Geryonid and the Cunina larvæ found in its stomach, but that they gain entrance from outside and then multiply asexually, and that they are sometimes found on the inside of the bell, as well as in the stomach. He does not refer to McCrady, whose papers were published twenty years before, but he shows that the history of the parasitic larvæ found in Carmarina is essentially like that of the one which McCrady had found in Turritopsis.

There is one interesting difference, however, for in his species the original larva never becomes a medusa, but permanently retains its larval nature, budding off numerous larvæ which become medusæ. He calls attention to the fact that this is a true alternation of generations, the egg-larvæ being the first, and the larvæ which are budded from it the second generation.

This discovery, and his verification of McCrady's discovery that the larvæ are parasites, entitle his paper to an honorable position, but I cannot believe that his account of the minute structure and of the mode of development of the larva is correct, as it conflicts with all our knowledge of the subject. He says that the tentacles are developed on the edge of the mouth, that the buds are formed at the oral end, that the digestive cavity is formed by a peculiar infolding and splitting of the endoderm, and he figures the embryo as a two-layered gastrula, with an aboral mouth which has nothing to do with the definitive mouth of the larva; and as this account cannot be reconciled with our general knowledge of the subject, or with the careful observations which Metschnikoff made (52) several years later, I am compelled to believe that he has failed to interpret his observations correctly.

In the same year, 1875, Schulze showed (58) that there is no organic connection between the Geryonid and the larvæ found on its gastrostyle, and he therefore decides that the Cunina embryo originates outside the Geryonid, and after fastening itself to its gastrostyle, gives rise to new larvæ by budding, as Uljanin also shows to be the case.

In December, 1881, Metschnikoff published an illustrated paper (52), in which he traced the embryology of the parasitic larva found in Carmarina, showing that the group of medusa-buds is formed by budding from the aboral surface of a ciliated egg-embryo, which gains access to the digestive cavity and there multiplies asexually. In this species, *Cunocantha parasitica*, Haeck., the egg-embryo, which in all probability corresponds to the *mother bud* of *Cunina rhododactyla* and to the larva shown in our figure 1, is very much degraded. It fastens itself to its host by means of pseudopodia which are thrown out at the oral end from a very peculiar large cell, which fills its digestive tract. It develops tentacles, but never acquires an umbrella or a proboscis, and soon begins to produce medusa-buds from an aboral stolon.

As Uljanin has shown, it does not become converted into a medusa, but is simply a nurse for the production of medusa-buds. This species therefore presents an example of a true alternation of generations, since the embryo which hatches from the egg remains as a larva and never becomes a medusa, although it gives rise to buds which do become medusæ.

In many respects Metschnikoff's observations upon the structure of the egg-embryo are in conflict with Uljanin's account; but as it is impossible to reconcile the statements of the latter writer with our general knowledge of the subject, I think we may safely conclude that Metschnikoff's account is the more trustworthy.

Both authors agree that the egg-embryo of the species which occurs in the stomach of Carmarina is degraded and has no umbrella, while Metschnikoff shows that the proboscis also is absent.

The next paper in historical order is a short one which Fewkes published in 1881 (19). He gives a brief account, with one figure, of Cunina larvæ which he found at Villafranca, attached to the gastrostyle of Carmarina, and he verifies Uljanin's statement that the larvæ are sometimes found on other parts of the medusa. He has observed them on the umbrella.

The youngest larva which he found was attached to the tip of the gastrostyle. It was solitary and he regards it as an egg-embryo destined to develop a stolon and to give rise to medusa-buds. He states that it was furnished with a long proboscis and a diminutive bell, and was almost identical with the youngest larva figured by McCrady, which, however, has a short proboscis and no bell, and it is impossible to reconcile his account with the observations by Uljanin and Metschnikoff, which show that the nurse is, in the species which they found in Carmarina, greatly degraded and has neither proboscis nor umbrella. His description is inaccurate, or else his species is a new one; and if the latter is the case it is to be hoped that his drawings and a more minute description will soon be published.

Fewkes attempts to show that there is a morphological similarity between a Siphonophore and the clusters of Cunina buds which are found in Carmarina. In support of this view he states that "these clusters or colonies of young Cuninæ, as is well known, ultimately dissolve their connection with the stolon and swim away as free medusæ." If he means by this sentence that the *clusters or colonies* swim away, the phenomenon is neither "well known" nor supported by a single published observation. If he means simply that each medusa-bud is detached from the stolon and becomes a free medusa, there is little resemblance to a Siphonophore; nor does our knowledge of the subject furnish any basis for his statement, p. 305, that the stolon which carries the buds is a modified proboscis.

He says "Cunina has become degenerated by its parasitism or commensalism so that the proboscis with young budding from it alone remains. Its bell has gone, the mouth opening is no longer functional, and the proboscis, which has elongated into a stolon attached to the body of a host, is closely crowded with the young;" but Metschnikoff's account of this particular form, shows that here, as in all other Cuninas which have been studied, the stolon arises from the aboral surface and has nothing to do with the proboscis.

This paper completes the long list of observations upon this interesting subject, and it may now be well to summarize the history of research regarding the parasitism of Cunina.

1. In Ægineta and Æginopsis the egg gives rise to the ciliated planula, which acquires a mouth, a short proboscis and tentacles, and thus becomes a free hydra or actinula, which is directly metamorphosed into a medusa. One egg gives rise to a

single larva and this becomes converted into a single adult. There is no asexual multiplication, no parasitism and no alternation of generations.

2. In *Cunina octonaria*, the hydra embryo, while still ciliated like a planula, but furnished with a mouth and two tentacles, gains access to the bell of a Hydromedusa, Turritopsis, where it lives as a parasite, and produces other larvæ, like itself, by budding. The first larva, like all the others, becomes a medusa, so that we have budding and parasitism, but no alternation.

3. The Cunina larva, which inhabits Geryonids, is essentially similar, but the first larva or egg-embryo does not become a medusa, so that we have alternation as well as budding and parasitism.

4. As no one has proved that the Cunina larvæ found in Cuninas do not pass in from outside, and as their history is like that of the species above noticed, there is every reason for believing that they also are parasites.

Section II. The Trachomedusæ.

Plates 41, 42.

Liriope is a representative of the third of the four orders into which Haeckel divides the Hydromedusæ; the *Trachomedusæ*, or veiled medusæ, with auditory tentacles, which are either free on the bell margin or inclosed in auditory vesicles, with endodermal otolith-cells. Ocelli on tentacular bases usually absent. Reproductive organs on the course of the radial canals, which are four, six or eight in number, often with blind centripetal canals between them. Veil, thin and wide. Ontogeny, as far as it is known, hypogenesis or direct development without alternation, but usually with metamorphosis.

It is a representative of his fourth family or the *Geryonidæ:* Trachomedusæ with four or six radial canals, with broad, leaf-like reproductive organs; a long proboscis, eight or twelve peronia, and closed auditory vesicles, which lie on the axial sides of the peronia in the gelatinous substance of the umbrella-margin; and to the first subfamily, the Liriopidæ, or Geryonidæ with four radial canals, four reproductive organs and eight auditory vesicles. He divides the subfamily into two genera: Lirantha with eight permanent tentacles in the adult; and Liriope, with only four; and he places our species in the first genus.

Haeckel has undertaken the very perplexing and laborious task of introducing order and system into the confused mass of fragmentary observations which have been printed regarding the Geryonidæ, and as his writings upon the subject introduce order where all had been confusion, and as he himself is more familiar than any other naturalist with the species and genera of the family, I hesitate to depart in any particular from his system: but inasmuch as specimens of our *Liriope scutigera* are sometimes found with four, five, six or seven tentacles, as well as specimens with the unusual number eight, I cannot believe that his two genera Liriantha and Liriope are natural, and I therefore retain the generic name Liriope for our species. Fewkes' statement (Acalephs from the Tortugas, Bull. Mus. Comp. Zool., IX, No. 1, p. 279) that Haeckel bases his two genera upon the presence or absence of blind centripetal canals is inaccurate, as a reference to Haeckel will show.

The large figure at the top of Pl. 12, which is a photolithograph of a pen drawing made from nature, is the only figure of *Liriope scutigera* which has ever been published.

Liriope scutigera, *McCrady.*

Liriope scutigera, McCrady, 1857; Gymnophthalmata of Charleston Harbor, p. 106.
Liriope scutigera, L. Agassiz, 1862; Contributions IV, p. 365.
Liriope scutigera, Brooks, 1883; Studies, II, p. 175.
Liriantha scutigera, Haeckel, 1879; Medusen, p. 287.
Xanthea scutigera, Haeckel, 1864; Geryoniden, p. 21.

Species-Diagnosis. Umbrella, when relaxed in swimming or floating, about half as high as wide: but sub-spherical or almost cubical when violently contracted. Gastric peduncle conical, thick, about as long as diameter of umbrella, gradually diminishing in size from the base to the proximal end, where it terminates in a pointed, tongue-like process, which may be protruded from the mouth, which is quadrate, without lips. Reproductive organs nearly square with rounded corners, extending from near circular tube to top of sub-umbrella, and nearly meeting along the inter-radii. Four perradial flexible, contractile hollow tentacles, three or four times as long as the diameter of the umbrella, and four short stiff interradial tentacles, which are absent in a few exceptional adults. Eight sensory vesicles, one at the base of each interradial tentacle, and one a short distance from the base of each perradial tentacle.

Color. By transmitted light, the tip of the proboscis is purple; by reflected light it is green and the ovaries red.

Size. About one-third of an inch in diameter.

Habitat. Abundant all through the summer in Hampton Roads, Virginia; at Beaufort, North Carolina, and at Charleston, South Carolina. It is one of the most characteristic medusæ of our southern coast.

Ontogeny. Hypogenesis with metamorphosis.

Haeckel's diagnosis of the species, which is abstracted from McCrady's account, is in the main correct, but it contains several statements which are not strictly accurate, such as the statement that the umbrella is nearly spherical, that there is no tongue-like process and that the reproductive organs are round. The species is distinguished from Fritz Müller's *Liriope catherinensis* (Arch. f. Naturges. xxv, p. 310, pl. 11) by the fact that the reproductive organs are nearly square, instead of being elliptical, and by the fact that they reach nearly to the circular tube, while Müller's figures show quite an interval between them and the circular tube. The primary radial tentacles of the young also lack the terminal flagellum or hook which is shown in Müller's figures.

Haeckel has shown that Agassiz's *Liriope scutigera* (N. A. Acalephs, p. 60, fig. 87) is quite different from McCrady species, and this is also true of Fewkes' *Liriope scutigera,* (Studies of the jelly-fishes of Narragansett Bay, Bull. Mus. Comp. Zool., VIII, 8, p. 126, Pl. 6, figs. 7, 10, 11, 1881). There is a lack of agreement between the text and the figures of Fewkes' paper, as he says there are only four otocysts, while his figure shows four on one-half of the umbrella, but neither the text nor the figures correctly represent *L. scutigera*, McCrady.

Special Description. McCrady's description of this species is so very vivid and minute, that, although he gives no figures, there is not the least difficulty in identifying the species, thousands of specimens of which may be procured at any point between Charleston and the Chesapeake Bay. His account of the habits of the animal is so graphic that I quote it: "This species is evidently gregarious, great numbers being found together in nearly every instance when I have found it at all. It is bold and rapid in its movements and very rapacious. I have seen one of this species, so extremely diaphanous as to make the impression of nothing but a set of outlines, seize upon a small fish fully thrice as large as itself, and securing itself by spreading out its lips upon it, making them act as suckers, and then entangling about the poor animal its four long tentaculæ, hang on in this manner despite the violent struggles of the fish which, alarmed, swam violently about the jar, until at last apparently from sheer exhaustion, it was evident he was dying. At last changing color, the fish turned over on his side and expired." McCrady speaks of the great size and circular form of the reproductive organs, but their shape may be more exactly described as square with rounded corners. He gives the following very accurate account of their general appearance. "They are four in number, and are so large that they very nearly touch each other laterally, and stretch very nearly from top to bottom of the disk-cavity, thus occupying almost the whole inner surface of the bell. When viewed from above their unyielding structure gives the disk a quadrate outline, and viewed in profile they appear as large, circular shields especially when at the death of the animal they assume a marked white coloration." The quadrate outline, however, is only apparent, except when the violent contraction of a freshly caught or a dying specimen causes the substance of the umbrella to conform to the shape of the distended ovaries. McCrady's account of the sense organs is somewhat misleading, owing to the fact that it is founded, in part, upon an examination of immature specimens. He says "the concretionary capsules are of two sorts, a small round vesicle containing a concretionary corpuscle at each of the shorter and complex tentacula, and at each of the longer and simple tentacula, a *double* capsule consisting of two cysts, one above the other, and connected by an intermediate (tubular?) thread, apparently a continuation of the membrane of the cysts." This second cyst, with its connecting thread, is really the degenerated primary radial tentacle of the young medusa. It must not be confused with the interradial club-shaped structure described and figured by Fewkes (Pl. vi, figs. 7 and 11.)

The Embryology and Metamorphosis of *Liriope scutigera*, McCrady, and the Life-History of the Geryonidæ.

Since the publication, in 1856, of Leuckart's observation on the metamorphosis of *Geryonia exigua* (17) naturalists have been aware that the young Geryonid is quite different from the adult, and that, during its youth, it undergoes a complicated metamorphosis.

It is generally stated in the monographs as well as in the text books that although the young medusa is unlike the adult, there are no true larval stages, since the egg gives rise directly to a medusa, which becomes metamorphosed, through a series of changes, into the adult.

This is, as I shall show, an erroneous interpretation of the facts, for the published accounts, when rightly interpreted, show that the larva actually passes, like other hydromedusæ, through a planula stage and a hydra stage, although naturalists have been misled by the fact that the hydra-larva is locomotive, and as it does not multiply asexually the fact that it is a true hydra has been entirely overlooked; and, so far as I am aware, not a single naturalist has noticed the existence of a hydra stage.

Most writers in fact have been so firmly impressed with the belief that medusæ have originated from sessile hydroid communities, that they have not only overlooked this stage in the development of the Geryonidæ, but they have expressly stated that it has disappeared. Thus Balfour states (65, p. 153) that The Trachomedusæ are * * * "probably derived from gonophores in which the trophosome disappeared from the developmental cycle," and Haeckel says (31) of the development of the Trachomedusae: "This form of ontogenesis is to be regarded as a secondary or cenogenetic process, which has originated from the primitive metagenetic mode of development through the loss of the polyp generation." See also Lendenfeld (46, p. 148).

So far as I am aware, Böhm is the only writer who has recognized the possibility of any other explanation, and he dismisses the subject very briefly and makes no reference to the Trachomedusæ, although he does not believe that alternation of generations is primitive, and suggests (9, p. 158) that "Lucernaria, the Ctenophora, the free Siphonophora (*and possibly some of the medusa without a polyp-generation?*) may be the direct descendants of a free ancestral form without the intervention of a sessile stage."

The total absence of anything like alternation of generations gives especial importance to the occurrence of a hydra stage in the life-history of the Geryonidæ, and furnishes a key for the interpretation of the more complicated life-histories of other Hydromedusæ, proving, as I think, the correctness of the view so briefly hinted by Böhm; and I therefore give in Pl. 41 figures of various stages in the life of *Liriope scutigera*. The development of this species has never been described, although we have in Fol's paper on the embryology of *Geryonia fungiformis* (22) and those by Metschnikoff (51, 52) on *Geryonia fungiformis*, *Geryonia hastata* and *Liriope eurybia*, a very complete history of closely allied species.

Ray Lankester has stated in a recent paper that Fol, in his well known and valuable monograph "has completely failed to give even an approximately correct account of them atter" and that Metschnikoff's description is "erroneous" (45). As my own observations on our American Liriope agree in every essential particular with the accounts by Fol and Metschnikoff it seems proper to give, in detail, my verification of the excellent researches which are thus sweepingly condemned.

I have been able to add a few points, such as the origin of the mouth, and of the radial canals, but my observations show that the development of our Liriope is, in all essentials, like that of the European Geryonidæ.

Our species appears to be very regular in its breeding habits, and specimens captured at all hours of the day laid their eggs at about 8 P. M., the eggs passing out of the mouth. Fol says that when he kept female specimens of *Geryonia fungiformis* by themselves they did not lay their eggs, but that as soon as a mature male was placed with them and discharged the contents of his reproductive organs into the water, the females at once deposited their eggs (22).

This was not the case with our species, for when I placed a single female by itself it discharged its eggs promptly at the proper hour. In two or three cases these eggs were not fertilized and soon died, without exhibiting any evidence of vitality, but in other cases the eggs laid by an isolated female developed normally. Schulze has shown, however, that hermaphrodite Geryonidæ sometimes occur, and these females may possibly have been hermaphrodites; but the occurrence or absence of fertilization makes no difference in the time of oviposition.

The eggs develop very rapidly and at six o'clock the next morning the embryos are in the stage shown in Pl. 9, fig. 3, so that it is necessary to keep them under observation all night in order to study the early stages. The segmentation of the egg and the formation of the ciliated embryo have been correctly and very minutely described by Fol (22) and by Metschnikoff; and, as is well known, the origin of the germ-layers is very peculiar and without any exact parallel. The transparent spherical egg, which consists of a peripheral layer of granular protoplasm, and a central less granular portion, in which the protoplasm is finely reticulated, undergoes total regular segmentation, and gives rise to a spherical embryo, composed of a single layer of larger cells, arranged around a small central segmentation cavity.

Each of these cells consists of an internal transparent reticulated portion, and an outer more granular portion, Pl. 41, fig. 1, *a*+*b*. Soon the outer granular portion, fig. 1, *a*, separates from the transparent portion *b*, leaving this as an independent endoderm cell inside the layer of ectoderm, which is formed from the outer granular ends of the blastoderm cells. This division of each blastoderm cell into a central endodermal cell, and an outer ectodermal one, does not take place in all parts of the egg at the same time, and eggs may easily be found in the stage which is shown in fig. 1, where two distinct layers are present on one side only. The central cavity, the segmentation cavity, persists, and ultimately becomes converted into the chymiferous tubes, and the stomach of the adult medusa. Before the delamination of the blastoderm cells is completed, the ectoderm cells begin to multiply by division, and the ectoderm cells of the young embryo are therefore more numerous than the endoderm cells, which divide more slowly. At the end of the process of delamination, the embryo, fig. 2, consists of a continuous hollow spherical layer or shell of granular and slightly flattened ectoderm cells, fig. 2 *a*, and within this, and in contact with its inner surface, a second concentric hollow sphere, *e*, of large transparent rounded endoderm cells, with reticulated protoplasm, surrounding a small central digestive cavity, *d*. The gelatinous substance of the umbrella now begins to appear between the ectodermal shell and the endodermal one, thus stretching and flattening the ectoderm cells, which continue to increase in number and soon form a very thin layer of pavement epithelium, fig. 3, upon the outer surface of the gelatinous umbrella, *b*.

According to Fol, the gelatinous substance is not homogeneous, but is marked by fine striations, which radiate through it in all directions from the surfaces of the endoderm cells. The latter also increase in number, and become flattened as at *e*, in fig. 3, while the digestive cavity, fig. 3 *d*, becomes correspondingly enlarged. The endoderm cells preserve their reticulated structure, which is visible until after the tentacles of the medusa appear. When the gelatinous substance first appears, and for some time after, it is uniformly thick and almost perfectly spherical, and the endodermal shell is also spherical, concentric with the outer surface, and separated from the ectoderm at all points; but it soon approaches, and finally touches the ectoderm, at a point which is to become the oral pole of the medusa, and which is below in fig. 3. The gelatinous substance, which lies between the two layers, is absorbed at the oral pole during this process, and Fol makes the very satisfactory conjecture, that the force which pushes the endodermal sac to one side of the spherical embryo is produced by the more rapid secretion of the gelatinous substance at the aboral than at the oral pole. The embryo now changes its shape a little, and becomes slightly flattened at the ends of the principal or oral-aboral axis, and the cells of both layers become thickened around the oral pole, to form an oral area or *peristome*, *a'*, *e'*. At this period the embryo rises from the bottom and floats in the water, apparently at rest. Under the microscope, however, it is easy to see that it does not simply float, but swims about with a very slow uniform motion, and although I was not able to see any cilia, small floating particles were thrown away as if by the action of cilia, which are undoubtedly present upon part if not the whole of the ectoderm. Fol states (22, page 182) that, at this stage in the development of the very much larger embryo of *Geryonia fungiformis*, scattered cilia make their appearance over the whole ectoderm, and cilia are visible upon the oral area of our species at a later stage, as shown at *c*, in figs. 4 and 5.

The spherical larva, with its two concentric layers of cells separated from each other by a gelatinous umbrella, without a mouth or any other passage into its spacious digestive cavity, and swimming by means of ectodermal cilia, is at first sight very different from the embryos of other medusæ; but its peculiar appearance is due to the very early formation of the gelatinous substance of the umbrella. If this were absent or if it made its appearance at a later stage, the embryo would be a ciliated, mouthless, two-layered planula, almost exactly like an ordinary planula, after the endoderm and digestive cavity have made their appearance, but before the mouth has been formed. The Geryonidæ accordingly pass through a planula stage, directly comparable with the same stage in other hydroids, but complicated by the accelerated development of the digestive cavity and the gelatinous umbrella.

The origin of the endoderm, at a very early stage of segmentation, by the simultaneous delamination of the inner ends of all the blastoderm cells is clearly a modification of what occurs in ordinary hydroid planulæ, although the segmentation cavity persists as the digestive cavity, and the endoderm never forms a solid mass, as it certainly does in the planulæ of Hydractinia and Tubularia. In Eutima however the segmentation cavity persists as it does in Liriope, and this is no doubt true also of other hydroids.

The two naturalists who first described the development of the Geryonidæ, Fritz Müller (55) and Haeckel (30) published their accounts at a time when embryological knowledge was much less advanced than it is to-day and when comparatively little was known of the histological structure and significance of the hydroid larva. They both fell into the error of regarding the central capsule of cells as the sub-umbrella, and believed that the digestive cavity, and its endodermal walls originated at a much later period; but our present comparative knowledge of the embryology of other organisms would now lead us, even in the absence of any record of its later history, to regard the central cells as an endoderm, for the hypothesis that they are the ectoderm of the sub-umbrella implies that the Geryonoid embryo is fundamentally different from all other known hydroid embryos.

At the present day the fact that the central cells of an ordinary planula become the cells of the digestive cavity is, in itself, an evidence that the central cells of the Liriope embryo are their homologue and equivalent, and the later history of the embryo fully bears out this view of their nature, and puts out of question the acceptance of Fritz Müller's and Haeckel's interpretation.

The next change which takes place, the formation of the mouth, is shown in figs. 4 and 5. The cells of the oral area or peristome become ciliated and a depression appears in the centre of the outer or ectodermal area, and a similar internal one is found in the endoderm, as shown at *e* in fig. 4. These two depressions soon meet, and break through to form the mouth, fig. 5, *c*, the edges of which become ciliated. Food is now swept into the digestive cavity, although little growth takes place until the larva is much older. If the gelatinous substance at the stage shown in fig. 5 were absent, the larva would be identical in structure with a typical gastrula; but it is quite clear, from the account of its origin which I have given, that it is essentially different from the invaginate gastrulæ of ordinary metazoa, and that the mouth is not an orifice of invagination, but a younger structure than the digestive cavity. At this and the following stages there is a noteworthy difference between our species and those which were studied by Fol and Metschnikoff. In our species the endodermal capsule, fig. 5, *e* and fig. 7, which is now a stomach, retains its rounded outline, and ultimately becomes elongated along the principal axis, fig. 7, *d*. Metschnikoff says that, in *Geryonia hastata*, it becomes flattened so that its aboral wall is almost in contact with its oral (52, Pl. 11, figs. 10, 11 and 14), while in *Geryonia fungiformis*, according to Fol, the aboral side becomes pushed down into the oral half, so that it forms a double cup, with a very thin cup-shaped cavity. The absence of this flattening, in the American Liriope, shows that it has no important morphological significance.

The tentacles, *f*, now begin to grow out around the edge of the peristome, as shown in an oral view in fig. 6, and, in an oblique view in fig. 5. Two of them probably appear before the others, and in the stage shown in fig. 6, there are three: two, which are probably primary, opposite each other; and a third, 90° from these. A fourth soon appears opposite the third, and Fritz Müller's figures show that they are the primary radial tentacles, figs. 9, 10 and 11 *f*, of the medusa. They are solid, and consist of a layer of ectoderm, continuous at the base of the tentacle with the ectoderm of the edge of the peristome, and a solid endodermal axis, which may, in our species, be clearly seen to be continuous with the endodermal portion of the edge of the peristome. Fol says, (22, page 184) that he found it difficult to trace, in his larger embryos, any visible continuity between the endoderm cells of the tentacles and the wall of the stomach, but in our species there is no such difficulty. The endodermal origin of the axial cells of the tentacles of hydroids and medusæ is such a firmly established fact, that the presence of tentacles at this stage is, in itself, a proof that the digestive cavity is present, and would in the present condition of embryological science compel us to regard the central structure as an endoderm rather than an ectodermal sub-umbrella. The tentacles, fig. 8, *f* now rapidly elongate and their tips become enlarged and crowded with lasso-cells. Fritz Müller, Haeckel, Fol and Metschnikoff figure at this stage peculiar hook-like appendages which project beyond the enlarged tips of the tentacles, but I have not observed anything of the sort in our species.

The larva shown in fig. 8 is a very interesting one, for it is in all essential points a hydra with a gelatinous deposit between the ectoderm and the endoderm. It has a mouth, a peristome, and solid tentacles, but no bell cavity; and if the thick umbrella were absent, and the endoderm and ectoderm in contact, it would be almost exactly like the floating, solitary actinula of Tubularia. It swims through the water, and its ectoderm is probably ciliated, and I think that comparison will convince any one that the hydra-like stage is actually represented in the life-history of the Geryonidae; and that the Actinula, the Geryonid larva, and the Polyxenia larva shown in Metschnikoff's Pl. 3, fig. 11 (51) are modifications of the same type, a free, solitary, swimming hydra with solid tentacles. It is well known that the solid tentacles of the Geryonidae are transitory larval organs, and that the persistent radial tentacles of the adult, Pl. 12, fig. 1, are hollow, like those of ordinary Anthomedusæ and Leptomedusæ. This difference is in perfect harmony with the view that the larval tentacles are hydra tentacles, while those which persist are medusa tentacles.

According to Fol, who has given a very careful account of the changes which now follow, from the study of an embryo which is much larger than ours, and, therefore, more convenient for study, the periphery of the mouth area now thickens to form a circular rim, from which the ectoderm of the tentacles is derived; while the rim itself becomes the free edge of the umbrella, and gives rise on its inner side to a circular fold of ectoderm, which becomes the veil. The ectoderm cells of the peristome, between the rim and the mouth, become the epithelium of the sub-umbrella, which meets the endoderm around the mouth, where the line of demarcation between the two layers can be clearly seen.

Metschnikoff's account is like Fol's in all essentials, as he also says that the periphery of the mouth area becomes the free edge of the umbrella, and gives rise to the tentacles and velum, while the area between the velum and the mouth becomes the epithelium of the sub-umbrella; but Lankester states (15) that there is a "substantial disagreement" between Metschnikoff's statement (52, page 20), that "Der Centraltheil der Scheibe stülpt sich dagagen weiter in's Innere ein, um die äussere Bedeckung der Schirmhöhle darzustellen," and Fol's account. The two authors studied different genera, and we should not expect to find an exact agreement in every point, but I fail to discern any reason for questioning either of them, and certainly do not perceive any difference regarding any significant points. Lankester's claim, that the two accounts conflict with each other, seems to be the result of his desire to show that neither of them is correct, but that his own very different explanation of the process is the true one; and I, therefore, quote the words of Fol's account, for comparison with the statement which I have quoted from Metschnikoff.

He says (22, p. 185), "Der anfangs fast kugelige Schirm breitet sich mehr nach unten und aussen aus, und nimmt bald eine wirklich schirmförmige Gestalt an. Der Rand des Schirmes nimmt der Randwulst ein, welcher sich schnell ausdehnt und zugleich relative verdünnt.

Der Magen tritt dabei verhältnissmässig immer mehr in die Höhe, so dass er in den Grund einer, anfangs seichten, trichterförmigen, später tiefen, glockenförmigen Höhle zu liegen kommt. Letztere ist die wachsende Schirmhöhle. Ein Epithel kleidet ihre Wände aus, welches direct von der oralen Ectodermscheibe abstammt. Am Mundrande sieht man immer noch die Grenze zwichen Ento- und Ectoderm, welche ihrer verschiedenen Beschaffenheit wegen noch unterscheidbar sind."

For all morphological purposes it is a matter of no consequence whether the bell cavity is formed by a pushing in at its centre, or by the growth of its edges, or in both ways, and it is easy to understand that closely allied species may differ in this respect. This difference upon a minor detail is therefore no reason for doubting the accuracy of either Fol's or Metschnikoff's account.

The youngest medusa which I obtained in the open water is shown in Pl. 41, fig. 9. It is peculiarly interesting on account of the simple structure of its digestive cavity, and it presents a very early stage in the formation of the chymiferous tubes, the origin of which has never been traced.

It is true that Haeckel gives an account of the origin of these structures, and says that they are formed by differentiation of the epithelium of the sub-umbrella; but as we now know that the sub-umbrella is lined by ectoderm, no one would, at the present time, believe, without very conclusive evidence, that endodermal structures originate in this way, although, at the time Haeckel's paper was published, such an error was not unnatural.

Haeckel says (30 *b*, p. 136): "The gastrovascular system is differentiated from the cells which cover the velum and line the cavity of the bell as a sub-umbrella. This differentiation takes place in such a way that, on the bell margin, at the junction of the velum and the sub-umbrella, a broad strip of larger and thicker-walled cells becomes specialized as the embryonic circular tube. At the same time two similar strips, crossing each other in the middle of the arch of the sub-umbrella, and joining the bases of two opposite tentacles, are differentiated from the general surface of the sub-umbrella."

"These are the four radial canals, which, like the circular canal, are at first so wide that only four small four-sided areas of the sub-umbrella remain free and covered with the smaller, flatter and thin-walled epithelial cells."

According to Ray Lankester (15) Haeckel alone has given a correct account of the origin of the sub-umbrella; but I doubt whether any other embryologist would at the present day credit the statement that the endodermal chymiferous tubes are formed from the epithelium of the sub-umbrella, although such a statement was not, twenty years ago, intrinsically improbable.

My own observations show that Haeckel really observed the origin of the chymiferous tubes, although he failed to discover that they are formed by the differentiation of the walls of the digestive cavity, instead of those of the sub-umbrella.

At the stage shown in fig. 9, the oral layer of endoderm has been pushed in, by the formation of the sub-umbrella, until it is nearly in contact with the aboral wall, and the digestive cavity is thus reduced to a thin dome which is concentric with the sub-umbrella and extends to the bell margin. At four points on the four inter-radii and near the bell margin, the two layers of endoderm have come into contact with each other and fused to form four shield-shaped areas of adhesion, fig. 9, *i*. The stomach is thus divided, by the four areas of adhesion, into first, a spacious axial chamber or stomach proper, which reaches more than half-way down the bell; second, four short, wide, radial canals, *l*; and third, four short arcs of the circular tube, *m*, which unite the distal ends of the radial tubes with each other.

In older medusæ I have traced the gradual extension of the four areas of adhesion, figs. 10 and 11, *i*, *i*, until four narrow, sharply defined radial canals, *l*, and a circular canal, *m*, are produced, and I think there can be no doubt that, in a younger medusa than the one shown in fig. 9, the areas of adhesion would be still smaller, and that, in a still younger medusa they would be entirely absent, while the stomach would extend to the bell margin as a continuous cavity without interruption.

While I have not found a larva in this condition, a reference to Fritz Müller's (55) and Haeckel's papers (30) will show that both these authors have seen and correctly figured this stage of development. The larva shown in Haeckel's Pl. 1, fig. 35, is like our fig. 9, except that the areas of adhesion have not yet appeared, and the four quadrate, interradial areas, of which Haeckel speaks on p. 136, are, beyond doubt, the areas of adhesion.

Although both Fritz Müller and Haeckel were led astray in their interpretations, I believe that their figures correctly represent the larvæ, but this is not true of the figures which have been given by other authors.

Drawings which are touched up at home, from sketches made at the seashore, are very apt to become conventionalized, and I cannot help believing that the sharply defined radial canals which are shown by Leuckart (17) and Fewkes (68, pl. 7, fig. 2) in young Geryonids at about the same age as our fig. 9, were introduced into the drawings upon theoretical grounds, rather than from observation. This is certainly the case with Gegenbaur's figure (25) for he represents the canals as interradial.

It is interesting to note that the endoderm cells do not completely disappear in the areas of adhesion, even in the adult. The Hertwigs give (69, Pl. 1) two sections, figs. 2 and 9, through the bell margin of *Carmarina hastata*, and in each section they show a double layer of endoderm cells, *r'*, *l'*, in contact with each other, running up toward the axis of the bell from the oral side of the circular tube, with the epithelium of which they are continuous, although the cavity of the tube does not extend between them.

The observations here given show the correctness of Balfour's conjecture (65, p. 130) that "while the exact mode of formation of the gastrovascular canals of Geryonia has never been worked out, the presence in the adult of hypoblastic lamellæ, and the mode of formation in medusa-buds, justify us in believing, with the Hertwigs, that they are the remnants of a once continuous gastric cavity."

The metamorphosis of the young medusa has been well described by Fritz Müller and Haeckel. The bell gradually becomes flattened, as shown in fig. 11 and in Pl. 42, and the gastrostyle gradually grows down from the apex of the sub-umbrella, carrying with it the stomach and the oral ends of the radial canals, until, in the adult, the mouth and stomach are far below the level of the veil. At various stages in its life the medusa has three sets of tentacles, four in each, or twelve in all. Of these, one set is radial and larval, soon disappearing with the growth of the medusa. The second set, figs. 9 and 10, *h*, next appear, and in some species persist throughout life, while they are absent in the sexually mature medusæ of other species. They are interradial. The third set, fig. 10, *g*, fig. 11, *g*, are radial; and are the long tentacles of the adult medusa.

The primary radial tentacles, figs. 9, 10, 11, are larval organs. They are the first to make their appearance and they are present in very young medusæ. They are solid, consisting of a central axis of very large cartilage-like endoderm cells, and a surface layer of ectoderm which is thickened at the tip of the tentacle, to form a knob or bulb, which is crowded with lasso-cells.

When these tentacles first appear in the larva they are situated at the edge of the peristome, and when this becomes pushed in, to form the sub-umbrella, the tentacles spring from the edge of the umbrella, just outside the velum, and their endoderm is continuous with that of the circular edge of the digestive cavity; but as the medusæ grow, they are carried out on to the outer surface of the umbrella, some distance from its edge, as shown in fig. 9. A string of degenerated endoderm cells persists for some time between the base of the tentacle and the circular tube, and thus marks out the line along which the tentacle has migrated. There is also an ectodermal ridge, "Schirmspang," on the surface of the umbrella, running from its free edge to the base of the tentacle. These tentacles drop off before the medusa attains to its full size, and they are entirely absent in the adult.

The four primary interradial tentacles are the next to appear, figs. 9, 10, 11, *h*. They also are solid, but they are distinguished from the primary radials by the fact that the ectoderm of the axial side is thickened to form a number of ridges or incomplete rings, each of which is filled with large, oval lasso-cells. The stiff interradials are usually, carried turned up against the outer surface of the umbrella, with thin rings of lasso-cells facing outwards. They are, at first, situated on the bell margin, but they migrate, like the primary radials, and in the adult they are separated from the bell margin by an interval which is somewhat greater than the diameter of the circular tube, with which a row of degenerated endoderm cells connects the base of each tentacle, and there is also an ectodermal ridge or "Mantelspang" with large lasso-cells running from the axial surface of the base of the tentacle to the bell margin. According to Haeckel, the Geryonidæ are divided into two great groups: one group including those species in which the interradial tentacles are retained by the adult, and the other including those in which they disappear before maturity is reached.

In our species, however, there is no invariable rule. Most adults retain all four of them; but individuals with only three, two, one, or with none at all are sometimes found. It is possible, and in fact probable, that this is true of other species also, and that the presence or absence of these tentacles cannot be used as a diagnostic characteristic.

The third set of tentacles, the secondary radials, are always present in the adult. They appear as small buds, fig. 9, *g*, in the young medusa, and grow throughout life. They are very elastic and may be stretched out to four or five times the diameter of the bell, and they are seldom contracted to less than twice this diameter. They are hollow and their lasso-cells are arranged in prominent rings along the whole length of the tentacle.

Summary of the Development of Liriope.

The following features in the life-history of Liriope are especially important as a basis for comparison with other hydromedusæ in the attempt to trace the origin of alternation.

1. Each egg gives rise to no more than one adult medusa, and there is no alternation of generations or asexual process of multiplication.

2. The segmentation cavity persists as the digestive cavity, and the embryo is not a solid mass of cells at any stage of its development.

3. The process of delamination which results in the formation of the two germ layers takes place rapidly over the whole of the spherical blastoderm.

4. The metamorphosis is gradual and is not divided into well-marked stages separated from each other by sudden changes; but it may be divided into a planula period, a hydra period and a medusa period, although certain characteristics of the medusa appear during the planula and hydra periods, and certain characteristics of the hydra are retained after the medusa period is reached.

5. During the planula period the spherical embryo consists of a ciliated ectoderm, and a capacious digestive cavity which has no opening to the exterior and is bounded by a single spherical layer of endoderm cells concentric with the ectoderm, but separated from it by the gelatinous umbrella which is at first spherical and of uniform thickness.

6. The planula is converted into a hydra by the union of the ectoderm and endoderm at the oral pole, where the two layers become perforated to form the mouth, around which the ectoderm cells become differentiated into a sharply defined oral area or peristome, on the periphery of which four solid hydra-tentacles are developed. The hydra is free, does not multiply asexually and has a gelatinous umbrella. If this were absent it would be very similar to the actinula of Tubularia.

7. As the hydra becomes converted into the medusa the peristome becomes pushed inwards to form the sub-umbrella, at the top of which the mouth is situated; while the digestive cavity becomes converted into a dome with its edge at the bell margin. The ex-umbral and sub-umbral layers of endoderm are thus brought close together and they

now unite with each other over four interradial areas of adhesion which increase in size and convert the peripheral portion of the digestive cavity into a circular tube and four radial tubes.

8. The veil is formed around the periphery of the peristome. The solid radial hydra-tentacles disappear and the solid interradial tentacles and the hollow radial medusa-tentacles are developed. The larval tentacles do not disappear until all the characteristics of the medusa are acquired, so that there is a period, before maturity is reached, when the animal is both a hydra and a medusa.

9. During the hydra period there are no marginal sense organs.

Literature of the Development of the Geryonidæ.

In 1856 Leuckart pointed out (17) the fact that the young Geryonid medusa is quite different from the adult, and that its growth is accompanied by metamorphosis; and in 1857 Gegenbaur figured and described (25, p. 247, Pl. 8, fig. 12) a young Geryonid under the name *Eurybiopsis anisostyla*. Fritz Müller's minute and amply illustrated account of *Liriope catherinensis*, published in 1859 (55), is the first in which the absence of an alternation of generations is established. He gives an account of the metamorphosis of the medusa, and shows that the young embryo is a double spherule of cells, and that the central capsule has, at first, no opening; and he also figures an older embryo with a mouth, but without tentacles, although he supposed that the central cavity was the sub-umbrella, that the mouth was the opening of the umbrella, that the peristome was the veil, and that the embryo has, at this stage, no mouth or digestive tract. In his classic monograph, published in 1866, Haeckel gives beautifully illustrated figures of the metamorphosis of *Glossocodon eurybia*, (30 *b*) and *Carmarina hastata* (30*d*); but he falls into Fritz Muller's error regarding the embryo, and describes the endoderm as the sub-umbrella, stating that the digestive tract and chymiferous tubes are formed, at a later stage, by the differentiation or specialization of the sub-umbral ectoderm. In 1873 Fol (22) reared *Carmarina fungiformis* from the egg, and gave a complete account of its development, illustrated by beautiful figures, showing that the central cavity is the digestive cavity and that its endodermal cells arise by delamination from the blastoderm, that the mouth appears later, and that the ectoderm around it becomes the sub-umbral [illegible], around the edges of which the veil and tentacles are developed. Metschnikoff states (52) that his observations (51) are a year earlier than Fol's, but as Fol's paper was received Nov. 18, 1873, while Metschnikoff's was not published until Jan., 1884, the discovery belongs to Fol, although Metschnikoff's observations, which were made at Villafranca in 1870, agree with Fol's in all essential particulars.

Kowalevsky's Russian paper, which appeared in the same year, 1874, gives a totally different account of the early stages, as observed in *Carmarina hastata*. According to Metschnikoff's statement (52) and Leuckart's abstract in the Arch. f. Naturgeschichte, Kowalevsky observed the origin of the central capsule by delamination, but decides that its cells are converted into the gelatinous substance of the umbrella, and have nothing to do with the digestive tract, which originates by invagination at a later period.

We thus have three irreconcilable statements as to the fate of the central capsule and the origin of the endoderm. Haeckel and Fritz Muller say that the central capsule becomes the sub-umbrella, from the walls of which the digestive tract is subsequently formed; Fol and Metschnikoff hold that the central capsule is the digestive cavity, and that the sub-umbrella is an ectodermal structure of later origin; while Kowalevsky claims that the central capsule is neither endoderm nor sub-umbrella, but that it breaks down and becomes the gelatinous substance of the bell.

In the summer of 1882 I studied the embryology of *Liriope scutigera* in order to decide between these conflicting views, and quickly satisfied myself of the correctness of the accounts of Fol and Metschnikoff.

While I was engaged in this work I received Metschnikoff's last paper (52) dated Dec. 30, 1881, giving an account of his renewed study at Naples of the embryology of *Liriope eurybea*, Haeckel, and *Carmarina fungiformis*, Haeckel, resulting in the complete verification of the account which he published in 1871.

The next paper in historical order, "On Young Stages of Limnocodium and Geryonia," by Ray Lankester (15), is a very noteworthy example of "deductive biology;" for while the title would lead us to expect new observations on the young stages of the Geryonidæ, the paper contains nothing to show that the author has ever seen a Geryonid, either young or adult, and his statement (14) that the tentacles of the Trachomedusæ are solid would hardly be made by any one who had examined an adult Geryonid; nor for that matter would any one who is familiar with Eucope venture the statement that the Leptomedusæ all have hollow tentacles. In this connection see Hamann (32) and the Hertwigs (69, p. 72).

It is true that the paper does contain diagrammatic figures, page 200, to illustrate the development of the Trachomedusæ, but they are purely imaginary and unlike anything which has ever been observed, for the author has undertaken the very dangerous task of constructing embryology upon general ground rather than from observation.

As his theoretical views bring him into conflict with the careful observations of Fol and Metschnikoff, he attempts to show that there is a "substantial disagreement" between their accounts, and he does not hesitate to assert that "Fol has completely failed to give even an approximately correct account of the matter," while Metschnikoff's account is "erroneous."

The same author had published, a few months before, an account of an interesting medusa which was found in very great numbers, at various stages of growth, in a tank in which tropical water plants were cultivated in England. The medusa, Limnocodium, is remarkable in many respects, as it is very different from all the known species, and has, so far as we know, no close allies. Ray Lankester regards it as a Trachomedusa, although Allman, who described it on the same day in another place (70), considers it a Leptomedusa.

In his second paper (15) Ray Lankester gives figures of young medusæ which were found in the water with the adults, all of which were males, and although the young are similar in all respects to the medusa-buds of hydroids, and quite unlike any medusa-embryo which has ever been reared from the egg, he regards them as egg-embryos, and constructs upon them a new view of the embryology of the Trachomedusæ, although he did not rear them from the egg, and gives no reason for believing that they are egg-em-

[illegible] his opinion that the adult is a Trachomedusa, and must therefore develop [illegible] the egg, without the intervention of a hydra-stage.

The number of species of Trachomedusæ which have been reared from the egg is [illegible]), and these are all so different from Limnocodium, that the argument from analogy [illegible] very scanty grounds for rejecting all the published observations, and as a matter of fact, we may well doubt whether Limnocodium is a Trachomedusa at all, as none of [illegible] sons are conclusive. The younger ones are exactly like medusa-buds, with a closed [illegible] umbrella, a mouth and a manubrium which have no functional importance, and four [illegible] canals which appear before the opening of the sub-umbrella. In all these respects they [illegible] with medusa-buds and differ from all egg-embryos which have ever been described. There is, therefore, good reason for believing that they are buds, which are detached from fixed hydra, and this view furnishes an explanation of the fact, so puzzling to Lankester, that among thousands of specimens no females were found. In animals hatched from eggs, we should certainly expect to find both sexes, and when thousands of embryos occur, ripe females must be present, but a fixed hydroid community gives rise to medusæ of only one sex; and the occurrence in the tank, year after year, of thousands of male medusæ, at all stages of growth, without any females, is just what we should expect if they are all the progeny of a single hydroid community, which has been accidentally introduced into the tank, and there gives rise to medusæ by budding. The author does not hesitate to resort to hypothetical explanations, and he attempts to explain the absence of females (12) by the hypothesis that the females may be fixed while the males are free.

This may prove to be the case, but there is not a single fact in the history of the Hydromedusæ to give it the least support except his failure to find females and the fragmentary account of the life-history of Limnocodium is therefore an extremely narrow base upon which to construct the embryology of the Trachomedusæ in opposition to the observations of Fol and Metschnikoff.

Section III. The Anthomedusæ.

Plate 37.

Turritopsis is a craspedote or veiled medusa belonging to Haeckel's order ANTHOMEDUSÆ, [illegible] veiled medusæ without marginal vesicles or otoliths, with ocelli on the bases [illegible] tentacles, with the reproductive organs in the walls of the digestive cavity, and [illegible] (in most cases) four radiating tubes. The Anthomedusæ originate, by alternation, [illegible] from Hydroids.

[illegible] Anthomedusæ, Turritopsis is a representation of Haeckel's Family TIAR[illegible] Anthomedusæ with four broad oral lips, four wide radiating canals, simple un[illegible] tentacles, four separate reproductive organs in the walls of the stomach, and [illegible] Haeckel's Sub-Family PANDÆIDÆ, or Tiaridae with eight or more tenta-

[illegible] medusæ were unknown when McCrady's original diagnosis [illegible] published (18, p. 25) his characteristics of the genus include certain points which are now known to be shared by other genera, and others which are only of specific importance. Haeckel's diagnosis (31, p. 66) is based in part upon an erroneous interpretation of McCrady's account of our species, and I therefore give a new statement of the distinctive characteristics of the genus.

Genus-Diagnosis. Tiarid with numerous tentacles in a single row, and a single ocellus on the inner or axial side of the bulb of each. No gastric peduncle from the gelatinous substance of the umbrella, from which the digestive cavity is suspended by a cartilage-like mass, made up of the greatly enlarged endoderm cells of the radiating tubes. No mesenteries. Four simple perradial reproductive organs in the walls of the digestive cavity, separated by deep furrows with smooth surfaces. Oral lips fringed with stalked bunches of lasso-cells.

The stalk which suspends the digestive cavity of Turritopsis from the centre of the sub-umbrella is not a gelatinous prolongation from the umbrella, but a peculiar structure, made up of the greatly enlarged endoderm cells of the radiating tubes, which, in the adult, are pendent from the sub-umbrella, as in Haeckel's figures of Callitiara (3, Pl. 3) but so greatly thickened as to form a solid cartilage-like mass, through which the four small channels pass down to the digestive cavity, into which the chorda-cells also extend.

McCrady's figures and minute description of this structure are so very clear that there should be no room for mistake. He says (18, page 3) "The stomach surrounded by the ovaries occupies the lower half (of the peduncle), but above is *a mass of very large cells* filled with a clear substance like that in the upper part of the disk in Oceania. This portion is traversed by the four ascending chymiferous tubes, around which the large cells are arranged with much regularity, and which, on reaching the muscular disk, arch over it to descend through its substance as vertical tubes." On p. 5, he says, "Returning now to the vertical tubes, we find that before entering the tissues of the bell, they traverse the clear portion of the proboscis. Here they do not preserve the even, somewhat flattened form which they have in the disk, but assume a rather irregular outline. This appears to be due to the circumstance that the canal occupies the somewhat irregular cavity left between the juxtaposed ends of the large cells composing the transparent part of the proboscis. How these cells are arranged radiately is shown in a diagrammatic cross-section at fig. 7. A small quadrangular space is left between the four masses thus formed, which is, probably, filled with the same clear substance which fills the cells. The tissue so formed is not confined to the tubes, though it has there its greatest development; it spreads also downward over the several lobes, but in this portion the cells are very much smaller. Around the tubes the cells are of a somewhat pyramidal form, their bases turned outwards, the apices inwards, to meet the chymiferous canal."

Keferstein (36, p. 26) correctly describes the peduncle of his *Oceania polycirrha*, which is a true Turritopsis, as "made up of large transparent cells which look like a network;" but Haeckel (31, p. 66) misled, no doubt, by the close resemblance between Turritopsis and Callitiara, has described the structure as an ordinary gelatinous gastric stalk, although it is, in reality, a very different structure from the peduncle of Eutima or that of the Geryonidae.

McCrady failed to discover that the cells are nothing more than the greatly thickened walls of the radiating tubes, but in other particulars his account is very accurate, al-

[illegible] Fewkes states (21, page 153) under the heading *Turritopsis nutricola*, in his description of a medusa which he wrongly supposes to be a Turritopsis, that McCrady's description is "quite faulty," and that there is nothing which corresponds to his "long description of what he calls a cellular upper portion of the proboscis."

Distribution of the Genus. So far as our present knowledge goes, the genus is distributed as follows: Messina, Mediterranean (Kolliker, Gegenbaur, Keferstein, Ehlers, Haeckel); St. Vaast, Normandy (Keferstein); Australia (Peron & LeSueuer); Charleston, South Carolina, U. S. (McCrady); Beaufort, North Carolina (Brooks); Hampton Roads, Va. (Brooks); Naushon, Buzzard's Bay (A. Agassiz.)

Turritopsis nutricula, *McCrady*.

Turritopsis nutricula, McCrady, 1856. Description of *Oceania* (*Turritopsis*) *nutricula*, nov. spec. and the embryological history of a singular medusoid larva found in the cavity of its bell. Plates 4 & 5.

McCrady, 1857. Gymnophthalmata of Charleston Harbor, page 127, Plate 8.

L. Agassiz, 1865. Contributions IV, p. 347.

Haeckel, 1879. System der Medusen, p. 66.

Brooks, 1883. Studies Biol. Lab., II, p. 465.

Oceania nutricula, McCrady, 1856. Description, etc.

Modeeria multitentaculata, Fewkes, 1881. Bull. Mus. Comp. Zool., VIII, 8, page 149, Pl. 3, figs. 7, 8, 9.

Modeeria nutricola, Fewkes, 1882. Bull. Mus. Comp. Zool., IX, 8, page 295.

Species-Diagnosis. Umbrella nearly flat on top. In profile view the upper third is nearly rectangular, while the outline slopes outwards in lower two-thirds. Diameter of umbrella about three-fourths of height. The large proboscis nearly fills the upper portion of the sub-umbrella. The upper wider than the lower half, cubical, and made up of four masses of endoderm cells, perforated by the channels of the radiating tubes. Digestive cavity, making about half total length of proboscis, cubical, ending below in four simple large lips, fringed with stalked bunches of lasso-cells, and nearly reaching level of velum, or sometimes reaching below it. Four very large ovoidal reproductive organs, separated from each other by deep interradial furrows, rounded below but divided above into two lobes which run up for a short distance on sides of radiating tubes.

One hundred or more tentacles, placed close together around bell-margin, and consisting of an enlarged bulb, a long slender contractile shaft, and a slight terminal clavate enlargement. Tentacles capable of extension to three or four times diameter of umbrella [illegible] a single ocellus on axial side of basal bulb.

Color. Umbrella transparent-reddish brown; reproductive organs, reddish orange; [illegible] furrows, deep lake; lips frosted, base and tip of tentacles red, shaft a very [illegible]

Size. About 6 mm. wide, and 8 mm. high.

Other Stages. Larva a branching tubularian hydroid, with a fusiform body, and three irregular [illegible] filliform tentacles. It is a member of Weismann's genus Dendroclava, and it is so very similar to his *D. Dohrnii*, as to render it probable that this also is the larva of a Turritopsis. Stems from 8 mm. to 12 mm. high. Hydranths, pale yellowish red. Medusa-buds originate on stem at base of hydranth. Young medusa has eight tentacles, a small gelatinous peduncle, and no cellular peduncle. Mouth of young medusa simple. Velum of young with four radial and four interradial hemispherical pouches.

Habitat. Charleston, S. C. (McCrady); Beaufort, N. C. (Brooks); HamptonRoads, Va. (Brooks); Naushon, Buzzard's Bay (A. Agassiz).

Remarks. The description and figures which have been given by A. Agassiz (2, p. 167, figs. 269-270), and which are referred to by Haeckel (31, p. 65) as giving all we know of the metamorphosis of the medusa, do not represent a Turritopsis at all, but a quite different medusa.

Fewkes's *Modeeria multitentaculata* (21, p. 149, Pl. 3, figs. 7, 8 and 9) is a true Turritopsis and so far as I can judge from the figure, which is copied from a sketch made by A. Agassiz of a single specimen which he found in 1865 near Naushon in Buzzard's Bay, an immature specimen of our southern *T. nutricula*.

This seems to be the only recorded instance of its occurrence north of the Chesapeake Bay, where it is very rare. Verrill states (62, page 451) in his "List of species taken at the surface of the water on the southern coast of New England" that it was found there at night from July to September, but as he refers on page 734, to A. Agassiz's description and figures, which are noticed above, I infer, in the absence of all description, that the medusa which he found was the one which A. Agassiz figures, and not a Turritopsis.

Fewkes (21, p. 153) describes and figures a medusa which he calls *Turritopsis nutricola*, but which he was able to reconcile with McCrady's figures and description, only on the supposition that they are quite faulty. In a later paper (20, p. 294) he corrects this error, proposing a new name for his Turritopsis, and stating, incidentally, that his *Modeeria multitentaculata* is probably the same as McCrady's *Turritopsis nutricula*; an opinion which is undoubtedly correct. He says, however, that "as the generic name Modeeria is older than Turritopsis, and as they seem to have been applied to similar jelly fishes, McCrady's medusa may later be known as *Modeeria nutricula*;" but as Forbes, who established the genus Modeeria, states (23) that it includes only medusæ with four tentacles, there seems to be no good reason why it should supplant McCrady's name for medusæ with more than a hundred tentacles.

Special Description. McCrady gives the following vivid and accurate description of the general appearance and habits of this interesting medusa, which may be readily recognized by its reddish brown color, its square outline and its rapid zigzag movements.

"*Turritopsis nutricula* is a lively animal swimming gaily about, near the surface of the water, with very regular rhythmical pulsations. * * * Its motion in swimming is peculiar; though it does not shoot forward so far at every stroke as Sarsia, yet each throb of the disk gives it a considerable impetus. Now if we examine a Thaumantias, Geryonia; or Turris while swimming, we see it propelled by many successive pulsations in a straight line, corresponding to the vertical axis of the animal, but this is not the case in Turritopsis. The pulsations here are slow, measured, powerful, each appearing to have a more sp[illegible] design in it, than the oft-repeated pulsations of Thaumantias, and each, instead of moving the animal directly forward toward the point whither its whole course tends, propels it in a direction crossing that line diagonally, like the course of a ship in tacking or traverse-sailing. It is thus propelled first to one side of its course, and then to the other; its actual track being a zigzag. * * * This is the motion of Turritopsis when performing a long journey, but he may be often seen sporting about the surface, taking a few sidelong leaps like those described, and then, with the mouth of the bell downwards, expanding himself to the utmost, all his tentacula, which in progression were tightly curled up, now gradually disentangling and stretching themselves to their greatest length, turned upwards or horizontally, while the motionless parachute slowly sinks to the bottom (See Pl. 37, figs. *I* and *K*). However, the tentacula thus extended seem to be keenly alive to every passing particle, and every now and then, one or two or more of them may be seen to contract with great rapidity, as if they had come in contact with something to be seized or avoided. At this time the Turritopsis has spread all his snares, and his tentacula radiating on all sides, form a circle probably equally efficacious with the spider's web. Indeed I have found small Crustacea, their principal food, frequently dead or dying in the embrace of these tentacula, or rather simply hanging to them by invisible attachments, illustrating in another instance the deadly properties of these wonderful thread-cells. After, however, the Turritopsis has been sinking for some time (he may even allow himself to touch the bottom of the jar), he suddenly draws in, more or less, all his tentaculae, and beats up again toward the surface in the same old zigzag way, now and then running along for a little distance in a horizontal direction, but generally going quite up to the surface, and then expanding himself, mouth downwards, again to sink slowly towards the bottom. The animal may continue fishing in this way a whole morning."

As it is a hardy species it thrives perfectly in an aquarium, where its active movements and the graceful curling and unfolding of its long hair-like tentacles, as well as its bright color, render it very attractive. A specimen may, if supplied with proper food, be kept all summer, but it is very voracious, and I have seen a small specimen kill and finally swallow a Sagitta more than half an inch long, the Sagitta being bent like a bow in the middle and distending the whole body of the Turritopsis.

At Beaufort a few specimens may be found throughout the whole summer, but it is not very abundant inside the inlet until the end of August, although we frequently obtained good numbers outside in June and July. When the south wind, which blows almost constantly during these months, comes to an end, near the end of August, Turritopsis makes its appearance inside the harbor, and with the continuance of calm weather, it becomes [illegible] abundant, and through September and October hundreds of specimens [illegible] ages and sizes may be captured nearly every day. I infer from this, that the hydroid [illegible] in deep water off shore, and that the proper home of the medusa is in the open [illegible]. Indeed, we have taken them at the bottom outside with the trawl, at times when [illegible] was so rough that none were found at the surface or inside the inlet. I have [illegible] single colony of the hydroid, and this was obtained inside the harbor.

Description of the Larva. In a previous paper (10, p. 195) I gave a brief account of the hydra and young medusa, which I am now able to supplement with illustrations and additional notes. Although I made many attempts to rear the young from the egg, I succeeded only once, and the planula is shown in Pl. 42, fig. 2. It is very opaque, and as I obtained very few, I did not sacrifice any of them for examination, and learned very little of the minute structure. In a living planula it is easy to make out, at the posterior end, an ectodermal invagination, which looks very much like the mouth of an invaginate gastrula, but this resemblance is misleading, for the careful study of a similar structure in the planula of Eutima shows that the invagination has no connection with the digestive cavity, but is an ectodermal gland for the attachment of the planula. My few planulae of Turritopsis attached themselves in the angle at the bottom of the aquarium, where examination was impossible, and I was not able to displace them without destroying them. Finally, I broke the glass, and was fortunately able to secure, among the fragments, one specimen which was uninjured, and this I have figured in Pl. 42, fig. 3. The figure shows that the planula does not become converted into a hydranth but forms a root, *a*, from which the first hydranth, *b*, is formed as a bud. This has as yet no mouth nor tentacles, but its oral end is enlarged and filled with lasso-cells.

The only colony of the hydra which I obtained was scraped from the piles of the steamboat wharf at Morehead City, seven or eight feet below low tide mark. The tips of two of its branches are shown at *H*, in Pl. 37. It lived for two weeks in the house, and set free great numbers of hardy medusae which were reared until they had acquired the characteristics of the genus.

The upright stems of the hydra, from 8 mm. to 12 mm. high, bore large terminal hydranths, as well as smaller ones which were scattered irregularly along the stem on short stalks. The long fusiform body of the hydranth carries from eighteen to twenty thick, short, filiform tentacles, which are arranged in three or more indefinite whorls. The medusa-buds, *B*, *B*, originate around the stem just below the hydranths, and they are themselves carried on short stems. The perisarc is not annulated, and it forms a loose cylindrical sheath around the main stem, and the short branches which carry the lateral hydranths and the young medusae, while the latter are closely invested by a much thinner and more transparent capsule of perisarc. The sheath on the stems is thick and crusted with foreign matter. It terminates abruptly by a sharp collar just below each hydranth. The young hydranths and the medusae are budded off above the collar, but they soon become entirely sheathed in perisarc by the growth of the stem. The pale yellowish-red hydranths, are very similar to those of Tubularia (Allman) and the hydroid is so similar to *Dendroclava Dohrnii* recently described by Weismann, that they undoubtedly belong in the same genus.

Metamorphosis of the Medusa. The little medusa remains attached to the stem, as shown in Pl. 37, *C*, for some time after the rupture of its capsule of perisarc. At this time it is nearly spherical and covered with large conspicuous ectoderm cells. Its eight short tentacles are thrown backwards in contact with the outer surface of the bell, and their tips are hooked or bent upon themselves in a very characteristic manner, which is shown in the figure. This position of the tentacle renders the bulb at the base, with its ocellus, very prominent.

The medusa when set free, Pl. 37, figs. *D* and *E*, has eight tentacles, a thin globular bell, and a short simple proboscis. When the animal is in active motion the tentacles are contracted, bent into hooks and thrown back against the umbrella, as shown in fig. *D*, and at each pulsation the bell is lengthened and emarginated during contraction, but when relaxed it is nearly globular. Fig. *D* shows a young medusa in the shape which it assumes while swimming, at each period of contraction, while E shows a medusa of the same age floating in a relaxed condition. When at rest the height of the umbrella is about equal to its diameter, and the shape is that of a spherical segment almost equal to a sphere. The tentacles are capable of extension to a length equal to about twice the diameter of the bell, and when the animal is at rest they are stretched out almost horizontally, and the distal half is bent downward a little at an obtuse angle near the middle of the tentacle. The four interradial tentacles, when thus extended, lie nearly in the plane of the velum, while the four perradial tentacles are carried a little lower. This peculiar bending and alternation of the tentacles, which is very characteristic, is well shown in fig. *E*, which, like all the other figures, is a careful study from life. Many hydroids carry their tentacles bent so as to form two cycles, and the resemblance to them which the young Turritopsis exhibits, seems to be an embryonic characteristic, for I have failed to observe anything of the sort in older medusæ. The tips of the extended tentacles are slightly clavate, each with a spot of dark orange pigment. The length of the proboscis of the young medusa is about two-thirds the height of the umbrella, and its upper and lower ends are smaller than the middle. The mouth of the medusa, when it is set free, and for several days afterwards, is simple and circular, and the endoderm of the oral end of the proboscis is thin; but, just below the aboral constriction, it becomes very thick and cartilage-like, and the thickened area arches out into the sub-umbral surfaces of the radiating tubes, as shown in fig. 7.

This thickening of the endodermal cells of the aboral end of the stomach is characteristic of the genus Turritopsis; and in a specimen a week old, fig. *H*, the whole upper half of the proboscis is made up of four great masses of very large, cartilage-like endoderm cells, which meet upon the central axis and run out for a short distance into the radiating tubes, which penetrate the masses of cells on their way to the stomach, the cavity of which lies below the cartilaginous peduncle. The singular structure which is thus formed is quite unlike anything which occurs in any other genus. It has been described by various authors as an ordinary gelatinous peduncle or gastrostyle, but it is not at all the same as the gelatinous projection from the substance of the umbrella which, in many medusæ, hangs down in the centre of the bell.

As the medusa grows the proximal ends of the radiating tubes are drawn down into the cavity of the umbrella, as shown in fig. *H*, until in specimens two weeks old the stomach is suspended some distance below the sub-umbrella by a transparent mass of large cells meeting in the central axis, and perforated by the four tubes. In the adult, figs. *I*, *J*, *K*, this body almost entirely fills the upper half of the cavity of the bell.

In medusæ a week old, fig. *H*, the four oral lobes or lips have made their appearance, and are fringed by the stalked bunches of large prominent lasso-cells which have been described in the adult by McCrady and others.

At about this time traces of the reproductive organs make their appearance in the walls of the proboscis at the lower ends of the masses of endoderm cells. The tentacles, at the stage shown in fig. *H*, are still carried in two cycles: the interradials being higher than the perradials. There are only eight, and no more were developed in the medusæ which I reared from the hydra, although I captured many specimens in the same state, and at all the following stages up to maturity.

In specimens from one to two weeks old the lower surface of the very wide velum, fig. *G*, is pushed out to form eight hemispherical pouches; four of them radial and four interradial, in the planes of the eight tentacles. They project so much that they are quite easily seen in a profile view, and I have represented them in fig. *H*. May they not be homologous with the pouches, which, in the ocellate medusæ become closed and converted into the marginal vesicles?

The adult medusa is shown in figs. *I*, *J* and *K*. When it is swimming up from the bottom the tentacles are carried tightly curled up close to the edge of the bell. When it reaches the surface they are suddenly extended on all sides, shown in fig. *K*. They are nearly straight, but their tips are a little bent and sometimes coiled. This attitude is preserved only for a few seconds and the medusa at once begins to sink towards the bottom, while the tentacles coil up at their tips and assume the position shown in fig. *I*. The bell also becomes flattened and nearly hemispherical, and before the animal reaches the bottom of the aquarium it usually assumes the appearance which is shown in fig. *J*. As it nears the bottom it suddenly draws in its tentacles and rises to the surface, and again extends them, as shown in fig. *K*.

The plate, which has been photo-lithographed from sketches and studies which were made from the living animals, may, I believe, be relied upon as a faithful picture of the life-history of Turritopsis, and I trust that this accuracy, which is often lacking in drawings which are carefully finished at home, may compensate for the roughness and lack of transparency which are unavoidable in a pen-and-ink sketch. The figures of the adult medusæ, *I*, *J*, *K*, are much less magnified than the others, which are all drawn to the same scale.

Eutima. Plates 38, 39, 40.

I have selected Eutima as an illustration of the life-history of the second of the four orders, into which Haeckel divides the Craspedota or veiled medusæ. This order, the LEPTOMEDUSÆ, includes the Craspedota which are set free as buds from an asexual Campanularian nurse and which have the reproductive organs on the radial canals. Ocelli on the bases of the tentacles are usually absent, and marginal vesicles are almost universally present, and are developed along the veil at its junction with the umbrella, and contain ectodermal otolith cells.

Haeckel divides the order into four families, in the third of which, the EUCOPIDÆ, or Leptomedusæ with marginal vesicles and four simple unbranched radial canals, Eutima is placed, being included in the third of Haeckel's sub-families, the EUTIMIDÆ or Eucopidæ with eight adradial marginal vesicles, and with the stomach at the end of a proboscis or peduncle.

The seventeen species which are enumerated by Haeckel are arranged by him in eight genera, five of which are new, and the eight genera are divided into two groups: the Sexorchidæ, or Eutimidæ with four reproductive organs, and the Octorchidæ or those with eight; but as the reproductive organs are sometimes four and sometimes eight in two of our species, we cannot regard this division as a natural one. Haeckel's genera differ in the number of reproductive organs, the presence or absence of marginal cirri, and the number of tentacles, but as all of these characteristics are either variable or subject to change during growth, it is possible that a more complete knowledge of the life-histories of species which have been described from single specimens will compel us to make a very considerable reduction in the number of genera.

Haeckel's personal familiarity with the medusæ undoubtedly exceeds that of any other writer, and all students must bear testimony to the great value of the laborious researches into the perplexing literature of the subject, the results of which he has given us in his "System der Medusen." My own studies have taught me the value of this work, and I hesitate to propose any change in Haeckel's classification; but his arrangement of the species of Eutimidæ is not even available as an artificial key, for his genus Eutima is characterized by the presence of only four reproductive organs and numerous marginal cirri, while all my specimens of *Eutima mira*, a species which he places in this genus, had eight reproductive organs, and while nearly all of them had marginal cirri a few had none. His genus Octorchandra is characterized by eight reproductive organs and numerous cirri; but McCrady says that our *Eutima variabilis* (*Octorchandra variabilis*, Haeckel) sometimes has only four reproductive organs, and my specimens had no marginal cirri.

The genus Eutima, as originally established by McCrady, is equivalent to Haeckel's family Eutimidæ, and as all the species are very closely related to each other, while several of them are as yet very imperfectly known, it does not seem practicable to divide them into a number of genera at present.

Genus-Diagnosis. Eucopidæ with eight adradial marginal vesicles, and with the stomach at the tip of a gelatinous peduncle from the apex of the umbrella. Reproductive organs linear in the course of the four radiating tubes, which themselves extend down the peduncle to the stomach.

Remarks. The reproductive organs are often disposed in two masses on each radiating tube, one on the sub-umbrella and one on the peduncle, as shown in Pl. 39, but McCrady states that some specimens bear them only on the peduncle, some only on the sub-umbrella and some in both positions, and I have found specimens of *Eutima mira* in which ova were scattered along the whole course of the tube, from near the bell margin to the base of the stomach, although as a rule they are divided into two well defined regions separated from each other by an area where the canal bears no ova. [illegible] is often longer on one of the tubes than it is on the other, and the two ovaries [illegible] are sometimes confluent, while those in the other quadrants are distinct. We [illegible] agree with McCrady that, far from furnishing a basis for a division [illegible] number of reproductive organs cannot even be used to separate species; [illegible] double or single, and that when single they may be placed either on [illegible] the sub-umbrella, or they may stretch over both regions without inter-[illegible] these variations may occur in one and the same species. In the two species which have been traced to their hydra stage, this is a Campanopsis, or a Campanularia-like hydroid without a calyx.

Eutima mira, *McCrady.*

Eutima mira, McCrady, 1857. Gymnopthalmata of Charleston Harbor, p. 88, Pl. 2, figs. 8 and 9.

L. Agassiz, 1862. Contributions, IV, p. 363.

A. Agassiz, 1865. N. A. Acalephæ, p. 116.

Haeckel, 1879. System der Medusen, p. 191.

Brooks, Studies Biol. Lab. 1882, p.

Species-Diagnosis. Umbrella, when contracted in swimming, nearly hemispherical, about two-thirds as high as wide. Proboscis slender, slightly enlarged at base, four or five times as long as the diameter of the bell. Stomach of greater diameter than the peduncle at its junction with the stomach, about three times as long as wide, quadrate in cross section, and less than half as long as the height of the bell. Edges of the mouth folded to form four everted radial lips, separated from each other by four interradial inverted folds. Reproductive organs linear, sometimes extending from near the edge of the bell nearly to the base of the stomach, sometimes divided into a sub-umbral and a peduncular portion, either of which may be present alone. Four tentacles, with enlarged hollow bulbs, six or seven times as long as diameter of bell, sometimes with basal cirri, sometimes without. Numerous marginal tubercles, with or without cirri. Marginal vesicles with one large medium otolith and two or three pairs of smaller ones. Bases of tentacles covered by hood-like gelatinous projections from the umbrella.

Color. Almost perfectly transparent, endoderm of tentacular bulbs yellowish red.

Size. Umbrella 12 or 13 mm. in diameter and about 8 mm. high.

Habitat. Charleston, S. C., McCrady; Beaufort, N. C., Brooks.

Remarks. This is a very active and graceful species and the specimens which I kept in aquaria were seldom at rest. When swimming the tentacles and proboscis are usually extended to their full length, as shown in Pl. 39, fig. 2, but when the animal is floating at rest or sinking to the bottom, the tentacles are swept into graceful folds by the resistance of the water, as shown in fig. 7. As the animal rises rapidly from the bottom the tentacles are thrown into undulations by the flapping of the bell. When contracted in swimming, the outline of the umbrella is nearly hemispherical, but when at rest it is slightly emarginated, as shown in McCrady's figure. In an oral or an aboral view, the outline of the umbrella is not circular but produced to form four rounded, radial projections or hoods over the bases of the tentacles. The enlarged bulbs at the bases of the tentacles taper rapidly into the slender, hollow shafts, which may be extended to seven times the diameter of the bell, and are never completely retracted but lie around the medusa in loose, irregular coils when it lies at rest on the bottom. In nearly all the specimens which I examined, the radial canals anastomose with each other through an irregular plexus of canals around the base of the peduncle, as shown in Pl. 39, fig. 3. Some specimens have coiled accessory tentacles on each side of the bulb of each radial, but these as well as the marginal cirri are often absent.

This species is very abundant at Beaufort in August and September, and it is usually found in company with *Liriope scutigera*, to which it bears a close superficial resemblance which may possibly be due to mimicry. This resemblance led Eschscholtz to associate these and allied medusæ with the Geryonidæ and it is expressed by the name Geryonopsidæ proposed by Agassiz for the Eutimidæ, Eirenidæ and related medusæ.

Ontogeny. I have reared the hydroid from the egg laid by the medusa. It is a Campanopsis very similar to the one from which Claus obtained the young medusæ of *Octorchis* (*Eutima*) *Gegenbauri*. It has a prominent, rounded manubrium, a single circlet of ten tentacles, arranged in two alternating series, and an elongated cylindrical body, which is not covered by the perisarc which invests the unannulated stem, Pl. 38, fig. 10.

Eutima variabilis, *McCrady*.

Pl. 39, fig. 1; Pl. 40.

Eutima variabilis, McCrady, 1857. Gymnophthalmata of Charleston Harbor, p. 88.
L. Agassiz, 1862. Contributions IV, p. 363.
A. Agassiz, 1865. N. A. Acalephæ, p. 116.
Octorchandra variabilis, Haeckel, 1877. Prodrom. System Med., Nr. 211.
Haeckel, 1879. System der Medusen, p. 199.
Eutima sp., Brooks, Studies Biol. Lab. 1882.

Species-Diagnosis. Umbrella thick, flattened, more than three times as wide as high Peduncle about equal in length to radius of bell, and less than twice as long as its height. Stomach short, quadrate, much folded, and prolonged into four pointed, crenulated lips. Sixteen tentacles of equal length, with three or four marginal thickenings between adjacent tentacles. Eight marginal bodies with ten or twelve otoliths in each; the medium one largest and the others in pairs. Each marginal vesicle lies close to radial sides of bulb of tentacle next radial tentacle. Reproductive organs usually divided into a sub-umbral and a peduncular portion; the latter absent in the young. No marginal cirri or accessory tentacles.

Color. Umbrella and peduncle transparent and colorless. Stomach and endoderm of tentacular bulbs intense green by reflected light. Endoderm of tentacular bulbs bright pink, and ectoderm sky-blue by transmitted light. Ectoderm of tentacular bulbs colorless by reflected light.

Size. Diameter of bell about 30 mm. Height about 7 mm.

Habitat. Charleston, S. C., McCrady: Beaufort, N. C., Brooks. It is a rare species at Beaufort and most of the specimens which I obtained were captured outside in August and September.

Ontogeny. Although I obtained ripe eggs on several occasions they were not fertilized and we have no direct knowledge of the ontogeny, although there is no reason to suppose that the hydra is different from that of *Octorchis* (*Eutima*) *Gegenbauri* and *Eutima mira*.

Remarks. McCrady's specimens had only twelve tentacles, while all the mature specimens which I obtained had sixteen, but as the Beaufort specimens agree with his [illegible] in all other respects, their identity can hardly be doubted. The tentacles were all of equal length, and were arranged as in this diagram, where *R* stands for a radial tentacle and *O* for a marginal vesicle.

R T T T R T T T R
O O O O

If the middle tentacle of each quadrant is the youngest one, the stage which is shown in Pl. 40 must be preceded by a stage with only twelve tentacles. This plate, which is a photographic copy of a pen sketch made from the living medusa, is the only figure which has ever been published of this beautiful species.

The tentacles of the adult have well-marked bulbs; their long, slender shafts are usually extended to four or five times the diameter of the bell, and are never completely retracted, but when shortened they are thrown into zigzag folds.

On Aug. 7, 1880, I obtained a single specimen of a Eutima with a thick, flattened umbrella, and four long, slender tentacles. It is shown in Pl. 39, fig. 1. It was 8 mm. in diameter and although it differs in many respects from the adult *Eutima variabilis*, it shows so many points of resemblance that it is, in all probability, the four-tentacled stage of this species. The bell is very flat, about four times as wide as high, thick in the middle, and gradually becoming thin at the edges. The peduncle is longer than the diameter of the bell, while the stomach is very short and only a little longer than wide. Veil very narrow. The four tentacles have bulbs, which are covered by hood-like outgrowths from the umbrella, and their long, slender shafts are capable of very limited contraction; and, when extended to four times the diameter of the bell, are thrown into zigzag folds. The four ovaries are long, narrow and continuous, and they run from near the circular tube up into base of peduncle and down this for a short distance. There are no accessory tentacles on the tentacular bulbs, but between each pair of tentacles, there are nine or ten marginal enlargements, some of which have cirri. The lips are simple folds, and there are eight marginal vesicles, each with from three to nine otoliths.

It is possible that Agassiz's *Eutima pyramidalis* may be the young of this species, although he states that the bell is hemispherical, which is certainly not the case with any of the specimens which I have seen.

A. Agassiz's *Eutima limpida* (2) and Fewkes's *Eutima gracilis* (20) are, beyond question, distinct from the species found at Beaufort, so that we have, on our coast, four species of the genus.

Eutima mira, with a hemispherical bell, and a very long proboscis, with folded lips, and with four tentacles; *Eutima variabilis* with sixteen long tentacles, a short proboscis and a flattened bell; *Eutima limpida* with short tentacles without bulbs, and with simple lips; *Eutima gracilis* with a flattened bell, four tentacles with bulbs, large cirri, accessory tentacles and a globular stomach. The latter species, which is so far known from only a single specimen, is very similar to Keferstein's *Siphonorhynchus insignis* (36) with which it may prove to be identical.

In June, 1879, I obtained at Beaufort several young specimens, about 5 mm. in diameter, of a young *Eutima* which agrees with A. Agassiz's description of *Eutima* *[illegible]* in so many respects that I am inclined to regard it as the young of that species. It is shown in Pl. 39, figs. 1, 5 and 6. It has a flattened, emarginated bell, simple lips and short tentacles without bulbs, and with accessory spiral tentacles. Specimens were also found at the same stage of growth in Aug., 1879 and Aug., 1880.

The Embryology and Metamorphosis of the Eutimidæ.

In 1881 Claus called attention to the fact that almost nothing is known regarding the life-history of Eutima or any of its nearest allies, and that the only observations upon the development of any of the Gerynopsidæ are those of A. Agassiz (2, p. 115, figs. 171 and 172) who has reared the planula of *Tima formosa* from the egg and has given a very brief description and a single figure of the hydra, although he did not observe the production of medusa-buds and says nothing about the very young stages of the medusa.

Except for Claus' paper, which will be noticed presently, the only addition to our knowledge of the subject is a very brief account by Merejkowsky (50) of the young embryo of Irene. In the spring of 1880, Claus (66) found a number of small hydroid communities in an aquarium, in which specimens of *Octorchis Gegenbauri*, *Irene pellucida* and *Æquora Forskalia* had been placed some time before. From these hydroids he obtained a number of young medusæ, which, however, he did not succeed in rearing; but, as he was able to collect in the open water series of young medusæ of each of the three species, he showed that those which he obtained from the hydroid were essentially different from young specimens of Irene and Æquora, while they were sufficiently like the youngest specimens of Octorchis which he obtained in the open ocean, to render it very probable that the hydroid belongs to this species, although the gap between the two is sufficiently great to render further information desirable. In the absence of any observations which connect the hydroid with its parent or the medusa-buds with adult medusæ, it is possible that the hydroid may not have been reared from the eggs of any one of the three species which were placed in the aquarium, as eggs or planulæ may have been introduced with the water. Claus' observations render it very probable that the hydroid is the larva of Octorchis, but they do not prove it beyond question, and I have been able to complete the story by actually rearing from the eggs of our *Eutima mira*, under constant observation, a hydroid which is so similar to the one which Claus figures, as to show beyond doubt that his conclusion is correct. Octorchis is a Eutima according to McCrady's definition of the genus, and the species which I studied is very closely related to the one which Claus observed. As I have observed the segmentation of the egg, the swimming life of the planula, its attachment and the origin of the hydroid, while Claus has described the medusa-buds and the metamorphosis of the medusa, the two accounts give a very complete life-history of the Eutimidæ.

The fertilized eggs of Eutima may be obtained by placing a few mature specimens in a small aquarium or a shallow dish of sea water. They usually lay their eggs the first day after they are captured, and if the species is very abundant, the water will often contain enough spermatozoa to fertilize them, even when only one specimen is used; but the result is much more certain if several specimens are placed in the same dish, for many of the eggs fail to develop if no males are present. Eutima is very regular in its breeding habits, and while my specimens were captured at all hours in the day, nearly all the eggs were laid between the hours of 7.30 and 8.30 P. M.

The tendency to lay eggs at a fixed hour of the day seems to be quite prevalent among marine animals, and a knowledge of this is of the greatest importance to naturalists, since a failure to procure the fertilized eggs of an animal may often be due to the fact that it has not been collected or observed at the proper hour. The phenomenon has received very little attention and I therefore give a few illustrations which have recently attracted my attention. Claus in 1882 (11) and Merejkowsky in 1883 (50) have shown that the young stages of Æquora and Obelia are found only in the morning, and Merejkowsky says that the successive steps in the formation of the planula of Obelia follow each other with such regularity that each stage is met with only at a definite hour in the morning. This author attributes the regularity to the direct influence of light, but he gives no proof of this and observations which have been made at Beaufort, under my direction, during the past three or four years, show that the periodicity is not due to any external influence, but that it is a specific characteristic determined within the organism. Wilson found at Beaufort that the eggs of Renilla, an Alcyonarian, which lives in the sand below low-tide mark, are always laid at or about 6 A. M. He observed only a single instance of spawning at 5.30 and it was never observed later than 7 A. M. The regularity is entirely independent of temperature, for the spawning hour was the same on cold and on warm days, although the rate at which the embryo develops does vary with the temperature. He says that the eggs of Leptogorgia are laid with the same regularity, although in this case the hour is 4 A. M. (67).

While Merejkowsky says that the eggs of Obelia are laid early in the morning, I find that several allied Beaufort medusæ spawn at night. Thus Eutima, Eirene, Turritopsis and Liriope discharge most of their eggs about 8 P. M., although captive specimens drop a few eggs irregularly at all hours. As one hydromedusa lays its eggs early in the morning, while other species lay them in the evening, the regulating influence can hardly be the supply of light.

While studying the development of a pelagic crustacean, Lucifer, I found that sexual union took place with great regularity, between 6 and 8 P. M.; while the eggs were laid between 8 and 10 P.M., so that the early stages can be studied only between 10 P. M. and 7 A. M.

Dr. H. H. Donaldson has observed at Beaufort that actiniæ of various genera are fully expanded only between the hours of 5 and 6 P. M. This is true of these animals in their natural homes, as well as in aquaria; and experiments showed that specimens which were kept in darkness expanded as promptly at the proper hour as those which were exposed to direct sunlight.

Among the animals which are here enumerated, some live at the surface, as Eutima and Obelia; some, such as the actinias, live near low-tide mark; some, Renilla for example, live in deeper water; and some, like Lucifer, are vigorous swimmers, while some, like Geryonia, are fixed. Wilson's observations show that the periodicity is not due to temperature, while Donaldson's experiments show that it is not the effect of light. There is no evidence to show that it is due in any way to the direct influence of surrounding conditions, and I think we must believe that it has been established in each species by natural selection on account of some advantage to the animals which exhibit it.

The fact that the hour for discharging the reproductive elements is, in so many species, a definite one, often in the night-time, shows the importance of marine observatories where the naturalist may keep his specimens under his eye at all hours of the day and night; for, as midnight collecting is usually impracticable, the early stages of many animals cannot be procured without facilities of this sort.

The eggs of *Eutima mira* develop rapidly, and the swimming planula stage is reached early in the morning after the eggs are laid.

Segmentation is total, but as shown in Pl. 38, fig. 1, it is not perfectly regular. A capacious segmentation cavity, fig. 8, *a*, soon makes its appearance, and the cells which are a little larger at one pole than they are at the other arrange themselves in a single layer, *b*, and continuing to subdivide soon become nearly uniform in size as shown in fig. 3. The embryo now becomes ciliated and, rising from the bottom, assumes the well-known pear-shaped outline of the hydroid planula, fig. 4, with a spacious segmentation cavity, surrounded by a single layer of ciliated cells, *b*, which are much thicker at the small end of the pear than over the rest of the body. While the blastoderm consists of only one layer of cells, the planula increases considerably in size, and appears to have some method of nourishing itself.

According to Merejkowsky (50) the central cavity of the planula of Obelia communicates with the exterior through a great number of minute pores which are situated between the blastoderm cells. He says the pores are large enough to permit small infusoria to pass through them into the central cavity where he has seen small animals swimming actively. He believes that these small organisms serve as food, and, although I have not been able to discover the pores in Eutima, I have satisfied myself that the planula does obtain food in some way and increases in size.

The endoderm cells soon begin to make their appearance at the small or posterior end of the cavity and are set free, as shown at *c*, in fig. 4. They soon arrange themselves in a continuous layer or endoderm over the whole inner surface as shown at *c*, in fig. 6. According to Merejkowsky, they are not formed by the transverse division or delamination of the blastoderm cells, but by migration, in the manner which has been described by Schultze, Metschnikoff and others in the sponge planula. In a preliminary paper on the life-history of Eutima (11) I have stated that they are formed by delamination, but as I made no attempt to watch the changes of a single cell, I did not actually witness the process of division and it is possible that they are not formed in this way but by migration. The formation of the endoderm cells goes on rapidly and the planula soon appears to become a solid mass of cells, fig. 5, but careful examination will show that a small central digestive cavity, fig. 5, *g*, persists in the axis of the embryo, although it is rendered almost invisible in the living planula by the increasing capacity of the endoderm cells, which are apparently distended, so that they almost meet in the centre. In a specimen which has been killed with osmic acid and stained with picro-carmine, they are flatter than they are in the living animal, and it is easy to see that they are arranged in a single layer to form the walls of the digestive cavity. Fig. 6 is a stained specimen of the same age as the one shown in fig. 5. In a surface view, *c*, the rounded ectoderm cells are seen and by focussing a little deeper, the polygonal outlines of the granular endoderm cells, *e*, come into view, while still deeper focussing shows an empty space, *g*, the stomach, around the edges of which the single layer of endoderm cells is seen in sectional view.

There can, of course, be no doubt that in most hydroids, the planula is at first solid, and that the digestive cavity does not make its appearance until some time after the cells are specialized into an ectoderm and an endoderm, and I think that the persistence of the segmentation cavity of Eutima as the digestive cavity and the absence of a solid stage must be regarded as a secondary modification of the ancestral history, although it is not impossible that the manner in which the endoderm and digestive cavity are formed in the Geryonidae (see below) may be the primitive one and the solid stage a secondary phenomenon.

The fact that a solid stage occurs in so many hydroids, in the Acraspeda (see Kowalevsky, 40) and in the Anthozoa (see Wilson, 67), as well as in the sponges, would seem however to indicate that the early appearance of the digestive cavity in Eutima and in the Geryonidae is not primitive but secondary.

I shall not enter upon the discussion of the relation of the embryology of the Hydromedusae to the gastrula theory, further than to point out that not a single hydroid gastrula has been observed; but that, in every species which has been studied, the digestive cavity has at first no opening to the exterior, and that the mouth is formed very much later than the stomach. Most writers believe, it is true, that the planula is a modified gastrula, and that its digestive cavity was originally invaginated from the exterior, but this is purely a deductive inference from the analogy of other animals. Thus Claus (11) describes the origin of the endoderm and digestive cavity of Æquora and Merejkowsky that of Obelia (50) as like that of Eutima, but both these writers state their opinion that the planula has originated through a modification of a primitive invaginate gastrula. Böhm says (p. 153) that it is natural to derive the Hydromedusae and sponges from an ancestral gastrula, *since in no other group is descent from this form so certain.*

No one can question the resemblance between an adult hydroid or sponge, and the gastrula stage of the ordinary metazoa, and there is every reason for believing that the almost universal occurrence of this larval stage indicates that the cœlomatous metazoa are the descendants of an ancestral form which was essentially like the existing cœlenterates and that these themselves are the divergent modifications of a common type, the gastrula or two-layered metazoon, with stomach and mouth; but it is quite conceivable that the cœlenterates themselves may be the descendants of a form with a stomach, but without a mouth, and that the planula stage may be the ontogenetic representative of this just as the gastrula stage is the ontogenetic representative of the adult cœlenterate. Most writers have started however with the assumption that, as the hydroids must be the descendants of a gastrula, the planula must be a modified gastrula; and one writer (32) has, with the greatest simplicity, given us the chain of reasoning which has led him to supply a missing gastrula stage in the life of the hydroids. Hamann says in his section on Segmentation and the formation of the Gastrula" that he was induced to study the subject by his belief that a planula stage did not exist and that the published accounts were wrong. He says, however, that in his studies of the embryos of Tubularia, Aglaophenia and several Plumularidae, which were entered upon in this frame of mind, he was unable to find anything like the formation of a gastrula by invagination; that the paper by Ciamician, in which the invaginate gastrula of Tubularia is figured, is a conglomeration of errors, and that in all the forms which he himself has studied, the embryo becomes a planula like that which Schultze had described for Cordylophora; but while his appeal to nature leads him to these facts he says, "I hold that while the hydroid planula does in fact originate by delamination, without a segmentation cavity, nevertheless the planula is just as truly a gastrula as it would be if it originated by epibole or in any other manner," and that Balfour's view that the planula stage of development represents a free swimming ancestral form in the history of the Cœlenterata, in which the mouth and the digestive cavity were absent, is untenable.

If we believe that the gastrula stage of the higher metazoa is the representative of an ancestral form like the adult hydroid, we certainly should not expect to find a gastrula stage in the embryology of the hydroids themselves; and the analogy of the animals above the hydroids is no reason for supposing that the planula is a modified gastrula if we believe that these forms are the descendants of an ancestral form which was itself a divergent branch from the cœlenterate stem. The planula stage is certainly dominant among the sponges, and the so-called gastrula is here beyond doubt a secondary larva. Kowalevsky has shown that the embryo of Lucernaria is a planula (40) and Fol states (22) that his examination of the embryos of Pelagia has shown the need for a renewed examination of the alleged gastrula stage, while Wilson (67) shows that the Renilla embryo is certainly not a gastrula, and as there is not a single observation of a gastrula in the Hydromedusae, we may, so far as this group is concerned, continue to speak of the larva as a planula.

Hamann says that since we have a planula in some hydroids, and *instead of this*, an actinula in others, we are compelled to believe that the life-history of the lower Cœlenterates is considerably modified and does not give us the primitive condition of things; Hamann's own observations show that the actinula of Tubularia is not the equivalent of the planula of other hydroids, but that it is preceded by a planula stage, although this is not free but contained within the medusa-bud, and not being locomotor has no cilia.

Merejkowsky, who has given us a minute account of the planula of Obelia (50), says that he found a few embryos of Irene, in what seemed to him to be an invaginate gastrula stage, but he made no minute study of them and did not rear them. Irene is very [illegible] related to Eutima, and it is interesting to note that, in Eutima, after the endoderm [illegible] digestive cavity are formed, and before the appearance of the mouth, there is an [illegible] invagination which is possibly what he has seen in Irene, although the study [illegible] stages shows that it is not a mouth, but an ectodermal adhesive gland. At [illegible] shown in fig. 6, there is a mouth-like aperture *f* at the small or pos[illegible] planula, and in the living animal it is easy to see that this is formed by [illegible] the surface. In a specimen which has been killed with osmic acid [illegible] -carmine, fig. 5, it is still more conspicuous, and is seen to be a spacious cavity, *f*, opening to the exterior and surrounded by a single layer of invaginated cells, which are continuous around the edge of the orifice with the ciliated cells of the surface of the body. As this invagination is very conspicuous while it is difficult to trace out the structure of the more opaque endoderm, the planula bears, at first sight, a very striking resemblance to an invaginate gastrula like that of the Echinoderms; but more careful examination shows that the digestive cavity, *g*, is already present, and surrounded by a continuous wall of endoderm cells, *e*, *e*, and that the endoderm as well as the ectoderm is infolded, and that the invagination does not communicate with the digestive cavity, and takes no part whatever in its formation. At a somewhat later stage, fig. 11, the endoderm becomes drawn away from the invagination, leaving this as an exclusively ectodermal structure.

I have observed a similar invagination at the small end of the planula of Turritopsis, Pl. 42, figs. 2 and 3, although the planula of this species is so opaque that the study of its internal structure is very difficult. The fact that the invagination is present in an Anthomedusa and a Leptomedusa gives a reason for believing that it occurs in other species as well and that future research may show that it is not at all unusual. At first, the orifice is terminal, as shown in figs. 5 and 6, and the invagination lies on the axis of the larva, but one lip or edge of the opening soon grows faster than the other and thus pushes the pouch on one side, fig. 11, *f*, which may be called ventral, since it is the surface by which the planula becomes attached; but, before attachment takes place, the whole structure is evaginated as shown in fig. 7, so that only a slight notch, *f*, remains to mark its position. Lasso-cells now begin to appear at the small end of the planula, the cilia are lost, and a delicate layer of transparent cement is thrown off from the ventral surface of the small end of the planula, as shown at *n* in fig. 8.

This soon hardens, and, entangling foreign particles, becomes the perisarc. When first attached, and for a short time after, the larva retains the shape which it had during the swimming stage, but it soon elongates, as shown in fig. 9, and becomes the sessile, creeping root, which ultimately produces a community of hydroids. For some time, its posterior end, figs. 9 and 10, *h*, is marked by a flattened pad of ectoderm cells, separated by a constriction from the ectoderm of the general surface of the body. This pad is the area which was invaginated during the swimming stage. The root has no mouth nor other opening to the exterior, and there is for some time no trace of the future hydranth; but a bud, fig. 9, soon grows out from the free end of the root and, developing a circlet of tentacles and a mouth, becomes the first hydranth, fig. 10. A second bud now grows out from the root on the proximal side or base of the first and this is soon followed by a third and so on. As the first hydranth is formed, like all the others, by budding from the root, the growth of the hydranth from the planula is rather a process of metagenesis than metamorphosis and this is not the only species of which this is true. The planula of Turritopsis, Pl. 42, figs. 2 and 3, also becomes a root from which the hydras bud, and I have observed the same thing in Hydractinia, where it has been frequently described; first by Wright (64) I believe. Merejkowsky shows that the hydranth of Obelia originates in the same way; that the planula becomes a star-shaped root from which the first hydranth grows out as a bud, and many other cases are recorded. In some forms the planula becomes directly converted into a single hydra, as in Tubularia, where there is no metagenesis, but in many other forms there is certainly a true alternation between the planula stage and the hydra stage.

The direct conversion of the ciliated, mouthless planula into the tentaculated stomatous hydra will, without doubt, be recognized as the primitive life-history; and the alternation of generations between the planula, or the root into which it becomes converted, and the hydras formed from it by budding, will, I think, be universally accepted as a secondary modification. I shall give, in the last section of this paper, my reasons for believing that the alternation of generations between the hydra and the medusa is not primitive but secondary, and that originally a tentaculated hydra-like larva became directly metamorphosed into a single medusa; and the fact that an alternation of generations between the planula and the hydra has been secondarily established in Hydractinia, Eutima and Obelia certainly shows that this view is not without the support of analogy.

The oldest hydranths of Eutima which I reared from the egg were like the large one in fig. 10. They had ten tentacles, five long ones alternating with five short ones, with their bases united by an intertentacular web, *k*, in the centre of which there is a rounded hemispherical manubrium, ending in a simple circular mouth, without oral tentacles.

Although the hydroid is Campanularia-like, the perisarc is not annulated and is confined to the root and stems and does not extend over the bodies of the hydranths, which therefore belong to Claus' genus Campanopsis (66) from which he has reared a medusa which is very closely related to Eutima, and which belongs to the same genus as originally established by McCrady. The metamorphosis of the young medusa has been well described by Claus for his species and there is no reason to suppose that ours is essentially different.

In the species which he studied, *Octorchis Gegenbauri*, the medusa-buds originate on the body of the hydranth, on short pedicels, and they are inclosed in mantles or capsules which are cellular and without a covering of perisarc. When set free, the bell of the medusa is deep, the height being somewhat greater than the radius. There is no peduncle, and the stomach, which is less than half as long as the depth of the sub-umbrella, ends in a simple mouth without lips. There are two opposite radial tentacles, the rudiments of two others, numerous solid marginal cirri, and eight adradial marginal vesicles, each with a single ocellus. Claus did not succeed in keeping the medusæ alive, but he traced in a series of captured specimens the gradual increase in the number of tentacles, the growth of the peduncle and lips and the development of the reproductive organs, the peduncular portions of which appear earlier than the sub-umbral portions.

The Origin of Alternation of Generations in the Hydromedusæ.

In the experimental sciences, the investigator seeks for the simplest manifestations of [illegible] which he wishes to study, and divests it, as far as possible, of all second-[illegible]. In the natural sciences where experiment is usually impossible, the [illegible] studied as they present themselves in nature; and the difficulties which any given problem presents depend, to a very great degree, upon the accidents which direct attention to examples and illustrations which are simple and easy to understand, or to those where the simple laws are obscured or hidden under secondary complications.

Just as Werner's geological speculations were colored by the peculiar nature of the region where he lived, so the speculations of zoologists upon the origin of the medusæ, and their relation to hydroids, have been complicated by the accident which has directed their attention to the wrong end of the problem and has caused the almost total neglect of the groups which furnish its solution.

The typical Hydromedusæ, the Tubularians or Anthomedusæ, and the Campanularians or Leptomedusæ, are found in abundance on every coast and the shortest visit at the seashore must bring them before the eyes of the naturalist; while the pelagic Trachomedusæ and Narcomedusæ, which are seldom found near the shore, are usually regarded as minor or aberrant groups and they usually occupy a very subordinate and secondary position in our general conception or mental picture of the Hydromedusæ, although they include nearly one-third of all the known species of Acraspeda and are, so far as diversity of structure is concerned, fully as important as the more familiar groups.

Most of the writers who have discussed the origin of the medusæ, and the significance of the alternation between them and the hydroids, have entirely ignored the Narcomedusæ and the Trachomedusæ; or else they have made only an incidental reference to these two groups, which actually furnish the clearest, simplest and most direct evidence which is attainable.

As soon as we perceive that there is no reason why we should believe that the medusæ which are set free from fixed hydroid communities are the most primitive, simply because they are the most familiar; and that Liriope, Ægina and Cunina are not, as Balfour (65) and Grobben (74) assert, medusæ which have lost their ancestral hydra stage, but simply solitary floating or swimming hydras which gradually grow into medusæ and which repeat, more or less exactly during their own ontogenetic development and gradual metamorphosis from the egg to the adult, the phylogenetic history of the medusa: the complicated problem disentangles itself and we feel at once that we have found the right end of the thread.

In Æginopsis, as Metschnikoff shows (30), the egg gives rise to a ciliated swimming planula, which acquires a mouth and tentacles and thus becomes directly and gradually converted into a floating hydra or *actinula* which is at first ciliated like the planula. The tentacular zone of the floating hydra now grows out into a flange or umbrella which carries the tentacles with it; sense organs and a veil are soon acquired and the hydra becomes a medusa.

The whole process is perfectly simple and direct; there is nothing like an alternation of generations and the single egg becomes a single medusa with an actinula stage, a floating hydra-like larval stage and a swimming medusa stage. The life-history is as simple and uninterrupted as that of any other animal which undergoes a metamorphosis, and it may be represented by the following simple diagram in which the sign of equality (=) denotes that the change is direct growth or metamorphosis rather than multiplication.

I. Æginopsis — *Egg = Planula = Actinula = Medusa* × < *Eggs.*

As the floating hydra stage of Tubularia is well known under the familiar name ***Actinula***, and as it seems desirable to use a special term for the free hydra stage of medusæ as distinguished from a sessile hydroid, I shall employ this word for this purpose, designating by it a free or floating hydra which may or may not be ciliated.

I have shown that we have in Liriope and its allies a life-history which is very similar to that of Æginopsis, with numerous secondary modifications, most of which are due to the fact that the gelatinous substance of the umbrella begins to be secreted between the endoderm and the ectoderm at a very early stage in the life of the embryo. The acceleration of the formation of the umbrella is exactly paralleled by innumerable similar phenomena in the lives of nearly all of the higher metazoa, and it therefore presents no difficulties; and if we imagine the gelatinous substance absent, the mouthless, untentaculated, ciliated Liriope larva, shown in Pl. 11, fig. 3, is obviously a planula with an outer layer of ectoderm and a central capsule of endoderm. It has a spacious digestive cavity; the two layers are separated by a gelatinous substance; and in our species, the cilia are restricted to a small part of the outer surface: but, in spite of these secondary modifications, it is clearly a planula. It soon acquires a mouth and four solid tentacles, and becomes converted into the floating hydra or actinula, shown in Pl. 41, fig. 8, with ectoderm, endoderm, stomach, mouth, lasso-cells, and four tentacles, but with neither subumbrella, sense organs nor veil. This larva becomes converted into an adult medusa by the growth of the tentacular zone into an umbrella, and by the acquisition of sense organs, precisely like the Æginopsis larva, and as each egg gives rise to only one adult the life-history is simple and direct, with a planula stage, a hydra stage and a final medusa stage, and it may therefore be represented by the same diagram as that which was used for Æginopsis.

II. Liriope — *Egg = Planula = Actinula = Medusa* × < *Eggs.*

In our common American Narcomedusa, *Cunina octonaria*, the fact that the larva is a true hydra was long ago pointed out by McCrady. The planula stage of this species has never been observed, but the resemblance between the ciliated, bitentaculated hydra shown in our Pl. 13, fig. 1 and Metschnikoff's account of the Æginopsis larva at the same stage is so close that we have every reason for believing that, in this species also, the hydra stage is preceded by a planula stage without a mouth or tentacles. The hydra ... acquires two more tentacles and is then fundamentally like the four-tentacled hy... of Liriope. The number of tentacles soon increases to eight, and as is shown in our ... and 4, the hydra becomes converted into a medusa by the outgrowth of the ten... zone and the acquisition of sense organs. So far, the life-history of our Cunina is ... that of Æginopsis or Liriope, but it is complicated by the occurrence of ...ication in the larva and also by parasitism. The actinula, or floating cili... gaining access to the sub-umbrella of a Turritopsis, gives rise to buds ... of its body, behind the circlet of tentacles; each of these buds is a hydra like the parent and, like it, becomes directly converted into a medusa. As these secondary hydras originate as buds, they are at first sessile, but they become detached while in the hydra stage, or at least before they are completely converted into true medusæ: the time of detachment is not constant and although the larvæ are at first sessile, and, therefore, not actinulæ, they serve to show that the boundary line between a floating actinula and a sessile hydra is an extremely faint one.

Owing to the occurrence of asexual multiplication, each Cunina egg may give rise to an indefinite number of adult medusæ, but as each larva becomes directly converted into a medusa by a process of growth, there is no alternation and the life-history may be represented by the following diagram:

Hydra = *Medusa* × < *Eggs.*
×
III. CUNINA OCTONARIA *Egg* = *Planula* = *Actinula* = *Medusa* × < *Eggs.*
×
Hydra = *Medusa* × < *Eggs.*

Here we have asexual multiplication without alternation, but in the Cuninæ which Uljanin and Metschnikoff studied there is a true alternation which is obviously of secondary origin and undoubtedly due to a very slight modification of such a life-history as the one shown in diagram III. The planula itself is very peculiar and is furnished with an anomalous pseudopodial apparatus for clinging to and fastening upon the gastric process of the Geryonid within which it becomes a parasite; and the actinula, or primary hydra, into which it becomes converted, never completes its development into a perfect, free medusa. It remains as a brood-stock, from which other larvæ are budded, and these are set free and become converted into medusæ so that the life-history is represented by the following diagram, in which for the first time, we find a true alternation:

IV. CUNINA (CUNOCANTHA) PARASITICA *Egg* = *Planula* = *Actinula* × { *Hydra* = *Medusa* × < *Eggs.* / *Hydra* = *Medusa* × < *Eggs.* / *Hydra* = *Medusa* × < *Eggs.* }

A comparison of Metschnikoff's account of the development of *Cunina* (*Cunocantha*) *parasitica*, and that which I have given of *Cunina octonaria*, will bring out an interesting and significant difference between them which I have not yet pointed out. In the American *Cunina*, the hydra-stage is well marked in the larvæ which are produced by budding as well as in the one which hatches from the egg. In Metschnikoff's species, however, the characteristics of the adult medusa begin to make their appearance in the secondary buds, almost as soon as the buds themselves appear, and it would be difficult to recognize a hydra-stage in the life of this species if we were not acquainted with the simpler life-history of the American *Cunina*. In Metschnikoff's species, the primary hydra is also greatly modified to fit it for its parasitic life, but in other respects its life-history is very similar to that of the ordinary hydroids; and if the acquisition of the medusa characteristics by the secondary buds were a little more accelerated so that their hydra characteristics were entirely, instead of almost, crowded out, we should have a life-history like this:

$$\text{V.}\quad \textit{Egg} = \textit{Planula} = \textit{Actinula} \times \begin{cases} \textit{Medusa} \times < \textit{Eggs.} \\ \textit{Medusa} \times < \textit{Eggs.} \\ \textit{Medusa} \times < \textit{Eggs.} \end{cases}$$

I know of no hydra which presents this life-history without modification, but there are many Campanularians and Tubularians in which the only modification is the acquisition by the actinula or primary hydra of the power to produce, in addition to the buds which become medusæ, other buds which remain in the hydra condition, and share with their parent, the primary hydra, the power to produce both kinds of buds. Thus in Perigonimus (Stomatoca), the egg gives rise to a planula which becomes the first hydra, and this produces other hydras like itself and builds up a hydroid cormus; and ultimately all these hydras give rise to buds which become directly converted into medusæ, the hydra-like stage being completely suppressed, and we have a life-history like this:

$$\begin{array}{rl}
\textit{Hydra} \times & \begin{cases} \textit{Medusa} \times < \textit{Eggs.} \\ \textit{Medusa} \times < \textit{Eggs.} \end{cases} \\
\times & \\
\textit{Hydra} \times & \begin{cases} \textit{Medusa} \times < \textit{Eggs.} \\ \textit{Medusa} \times < \textit{Eggs.} \end{cases} \\
\times & \\
\text{VI.}\quad \textit{Egg} = \textit{Planula} = \textit{Actinula or Primary Hydra} \times & \begin{cases} \textit{Medusa} \times < \textit{Eggs.} \\ \textit{Medusa} \times < \textit{Eggs.} \end{cases} \\
\times & \\
\textit{Hydra} \times & \begin{cases} \textit{Medusa} \times < \textit{Eggs.} \\ \textit{Medusa} \times < \textit{Eggs.} \end{cases} \\
\times & \\
\textit{Hydra} \times & \begin{cases} \textit{Medusa} \times < \textit{Eggs.} \\ \textit{Medusa} \times < \textit{Eggs.} \end{cases}
\end{array}$$

In Turritopsis we have essentially the same life-history, except that there is a secondary alternation between the primary hydra and the others. The planula does not become a hydra, but a mouthless, untentaculated root which is undoubtedly a degraded actinula or primary hydra. It does not give rise to medusa buds, but remains as a brood-stock or embryonic hydra from which fully developed hydras are formed by budding, and all of these produce medusa-buds, so the life-history is as follows:

$$\text{VII.}\quad \text{Turritopsis } \textit{Egg} = \textit{Planula} = \textit{Root} \times \begin{cases} \textit{Hydra} \times \begin{cases} \textit{Medusa} \times < \textit{Eggs.} \\ \textit{Medusa} \times < \textit{Eggs.} \end{cases} \\ \textit{Hydra} \times \begin{cases} \textit{Medusa} \times < \textit{Eggs.} \\ \textit{Medusa} \times < \textit{Eggs.} \end{cases} \\ \textit{Hydra} \times \begin{cases} \textit{Medusa} \times < \textit{Eggs.} \\ \textit{Medusa} \times < \textit{Eggs.} \end{cases} \end{cases}$$

In the ordinary Campanularians, with free Medusæ, we have a new element of com-[illegible] owing to the appearance of polymorphism. The ordinary hydras no longer give [illegible] to medusa-buds, and these are produced only on the reproductive hydras or blasto-[illegible]. In Eutima, which I shall take as an example of this group, we have another com-[illegible] which is very significant. As in Turritopsis, there is a secondary alternation [illegible]as, for as I have shown above, Pl. 36, fig. 9, the planula no longer becomes [illegible] hydra but forms a root from which the primary hydra is budded like [illegible] appear later.

As I have shown, this secondary alternation occurs in many hydroids, such as Hydractinia, Eutima, Turritopsis, Obelia (Merejkowsky) and others, and it was correctly described by Wright in Hydractinia in 1856; but, so far as I am aware, no one has pointed out that it is a true alternation, exactly like the alternation between the hydra and the medusa. It is certainly a secondary acquisition, as we may see from the fact that in Tubularia, Eudendrium and other hydroids, the planula becomes directly converted into a hydra. So far as this point is concerned, the life-history of Eutima or Hydractinia, and that of Tubularia or Eudendrium present the following contrast.

TUBULARIA *Egg* = *Planula* = *Actinula* = *Hydra* × *Hydra* × *Hydra*

with no alternation, while in the other forms we have

EUTIMA *Egg* = *Planula* = *Root* × { *Hydra*, *Hydra*, *Hydra* }

with an alternation.

The complete life-history of Eutima with its double alternation between the root and the hydranths, between the hydranths and the medusæ, and its polymorphism, and division of the hydranths into nutritive persons and blastostyles, may be represented as follows:

VIII. EUTIMA *Egg* = *Planula* = *Root* × {
- *Nutritive Hydra* × {
  - *Blastostyle* × { *Medusa* = *Eggs*. | *Medusa* = *Eggs*. | *Medusa* = *Eggs*. }
  - *Nutritive Hydra*
  }
- *Nutritive Hydra* × {
  - *Nutritive Hydra*
  - *Blastostyle* × { *Medusa* = *Eggs*. | *Medusa* = *Eggs*. | *Medusa* = *Eggs*. }
  }
}

In Podocoryne (Dysmorphosa) we have an extremely complex life-history which, however, is readily derivable from one like that of Eutima as just given. There is a secondary alternation between the root and the hydranths as in Eutima, and the polymorphism between the hydranths is more specialized, as we find not only nutritive polyps and blastostyles but defensive polyps as well; and as each medusa, in addition to its sexual function, also possesses the power to produce other medusæ by budding, the number of sexual animals which may be derived from a single egg is unlimited.

The following diagram represents the life-history of this species, except that the first generation of medusæ, like the second, gives rise to reproductive elements.

IX. Podocoryne.

Egg = Planula = Root ×

- *Nutritive Hydra* × { *Nutritive Hydra* / *Blastostyle* / *Defensive Hydra* } × { *Medusa* × { *Medusa* < *Eggs.* / *Medusa* < *Eggs.* } ; *Medusa* × { *Medusa* < *Eggs.* / *Medusa* < *Eggs.* } }

  ×

- *Nutritive Hydra* × { *Nutritive Hydra* / *Blastostyle* / *Defensive Hydra* } × { *Medusa* × { *Medusa* < *Eggs.* / *Medusa* < *Eggs.* } ; *Medusa* × { *Medusa* < *Eggs.* / *Medusa* < *Eggs.* } }

  ×

- *Nutritive Hydra* × { *Nutritive Hydra* / *Blastostyle* / *Defensive Hydra* } × { *Medusa* × { *Medusa* < *Eggs.* / *Medusa* < *Eggs.* } ; *Medusa* × { *Medusa* < *Eggs.* / *Medusa* < *Eggs.* } }

- *Nutritive Hydra* × { *Nutritive Hydra* / *Blastostyle* / *Defensive Hydra* } × { *Medusa* × { *Medusa* < *Eggs.* / *Medusa* < *Eggs.* } ; *Medusa* × { *Medusa* < *Eggs.* / *Medusa* < *Eggs.* } }

  ×

- *Nutritive Hydra* × { *Nutritive Hydra* / *Blastostyle* / *Defensive Hydra* } × { *Medusa* × { *Medusa* < *Eggs.* / *Medusa* < *Eggs.* } ; *Medusa* × { *Medusa* < *Eggs.* / *Medusa* < *Eggs.* } }

  ×

- *Nutritive Hydra* × { *Nutritive Hydra* / *Blastostyle* / *Defensive Hydra* } × { *Medusa* × { *Medusa* < *Eggs.* / *Medusa* < *Eggs.* } ; *Medusa* × { *Medusa* < *Eggs.* / *Medusa* < *Eggs.* } }

It is very probable that future research will show that even this complex diagram is too simple for some of the Hydromedusæ, and that there is, in some cases, a secondary alternation between the first generation of free medusæ and those which are produced by budding from this generation. The life-history of these proliferous medusæ has not been studied, as they are seldom found near laboratories and appliances for research, but there is reason to suspect that in some of them only those medusæ which are budded from the bodies of the medusæ of the first generation become sexually mature; and if future research should prove this we should have still another alternation between the asexual proliferous medusæ and their sexual descendants.

In Hydractinia, the cormi of which are so similar to those of Podocoryne that a drawing of one will correctly represent the other, the life-history begins to simplify itself by the degradation of the sexual medusæ into sessile buds, or reproductive organs, which, although still retain traces of their former independent locomotor existence; traces which have almost totally disappeared in Eudendrium and in many of the Campanularians.

The life-history of Hydractinia may be represented as follows:

X. Hydractinia *Egg* = *Planula* = *Root* ×	*Nutritive Hydra* ×	*Nutritive Hydra* / *Blastostyle* × / *Defensive Hydra*	*Medusa-Bud* / *Medusa-Bud*	*Eggs.* / *Eggs.*
	Nutritive Hydra ×	*Nutritive Hydra* / *Blastostyle* × / *Defensive Hydra*	*Medusa-Bud* / *Medusa-Bud*	*Eggs.* / *Eggs.*
	Nutritive Hydra ×	*Nutritive Hydra* / *Blastostyle* × / *Defensive Hydra*	*Medusa-Bud* / *Medusa-Bud*	*Eggs.* / *Eggs.*

Now, what is the significance of this remarkable series of life-histories? Most of the facts have long been known, but the most conflicting interpretations of them have been advanced, and the student who seeks in the various monographs upon the subject an exposition of the relation between the direct development of a single adult from each egg, which is characteristic of most animals, and the circuitous history which is so remarkably exhibited by the medusae, will find a speculative literature which is almost unlimited, but a total lack of agreement as to the true solution of this, the most interesting of all the problems involved in the life of these most interesting animals.

The view which I believe to be the true one is that the remote ancestor of the hydromedusæ was a solitary swimming hydra, or actinula, with no medusa stage, but probably with the power to multiply by budding. I believe that this pelagic animal gradually became more and more highly organized and more perfectly adapted for a swimming life, until it finally became converted into a medusa with a swimming bell and sense organs, developing directly from the egg without alternation, but exhibiting during its growth the stages through which it had passed during its evolution. After this stage of development had been reached I believe that the larva derived some advantage from attachment to other bodies, either as a parasite within other medusae, or as what may perhaps be called a semi-parasite, upon other floating bodies such as the fronds of algæ; and that it multiplied asexually in this sessile condition, giving rise to other larvæ like itself, all of which became medusæ.

I believe that the sessile or attached mode of life of the larvæ proved so advantageous to the species, that it was perpetuated by natural selection, and that the primary larva then gradually lost its tendency to become a medusa, but remained a sessile hydra, giving birth by budding to other larvæ which became sexual medusæ; and that the medusa-characteristics of these secondary larvae were accelerated, and that the primary larva gradually acquired, at the same time, the power to produce other larvæ which remained permanently, like itself, in the hydra-stage; that in this way the sessile hydra-communities with medusa-buds and free sexual medusæ were evolved; and that finally these communities became polymorphic by division of labor, and that the sessile habit proved so advantageous that the free medusæ became degraded into medusa-buds, or sexual buds on the bodies of the sessile hydras or on the blastostyles.

The view which is most generally accepted is the reverse of this. Thus Huxley (31) tells the student that the medusa is simply a reproductive organ which was originally sessile upon the body of the hydroid, and that it has gradually acquired its free habit of life and its power of locomotion in order to secure the diffusion of the reproductive elements. Gegenbaur (26) and Balfour (65) tell him that the medusa is not an organ but a person, homologous with a whole hydroid, not with a part of it as Huxley teaches; that the separation of the community into sessile nutritive hydra-persons and locomotor reproductive medusa-persons has been brought about by division of labor; that the hydra community is older than the medusa; that originally all the members of the community were alike; that gradually certain ones became set apart for reproduction; and that, finally, these latter were set free, and acquiring reproductive organs became locomotor medusæ and that this change was brought about in order to secure the diffusion of the reproductive elements. These authors also believe that after medusæ had been gradually evolved in this way for this purpose, circumstances changed in some unexplained way, so that the wide diffusion of the reproductive elements was no longer so essential and that the medusæ took the back track and retrograded into sessile medusa-buds.

Hamann (32) who also believes that the sessile community is the primitive form, and that the medusæ have been produced by the gradual specialization of certain members which were set apart as the reproductive members, holds that they gradually acquired the power of locomotion in order to secure cross-fertilization rather than the diffusion of the eggs.

In 1878 Böhm (9) showed that the opinion that the sessile community is the primitive form, presents insuperable difficulties and he points out many reasons for believing that both the fixed hydra and the locomotor medusa have been evolved from a floating actinula, and Claus, two years after (17), 1880, states very briefly his belief that the hydra-stage is a larva and the medusa simply the adult and that the alternation of generations is due to the fact that the larva has the power to multiply asexually and thus to produce a number of larvæ like itself. This view is identical with the one which I reached independently at about the same time, before I was acquainted with the conclusions of Böhm and Claus, from the evidence which I am now able to present in full with illustrations, and which is not the same as the evidence which led Claus and Böhm to the same result, for neither of these authors makes any special reference to the life-history of the Narcomedusæ and Trachomedusæ.

It seems to me that the facts which are given in this paper establish this view beyond controversy and I shall show in the review of the literature of the subject which is given further on that it is the only hypothesis to which there are not insuperable objections. Even if this were not the case, I think that a comparison of the life-histories which are represented in the nine diagrams given above would convince every one that they stand in some derivative relation to each other, and it is surely simpler to believe that the complicated life-history shown in diagram VIII has been derived from a simple one like that [illegible] diagram I, than it is to believe with Balfour, Hamann and Grobben that the [illegible] and Trachomedusæ have been produced as the reproductive members of [illegible] and that they have afterwards lost all traces of this ancestry.

[illegible] reasons which compel us to this conclusion will be brought out in the re[illegible] of the subject, but I wish to call attention here to one argument [illegible] elsewhere, although it seems to me to be entitled to great weight.

The union of the sexes is so important to animals which are not locomotor that, among the Arthropoda, a group which includes far more than half of all the animals known to us, the sessile barnacles are almost the only hermaphrodites.

If the medusæ have been formed by the specialization of members of a community, and if the sessile hydroid cormi are, as this hypothesis requires, very old and primitive, we should certainly expect to find them exhibiting the power to produce from a single cormus medusæ of both sexes, for Hydra, which is one of the most primitive hydroids, is hermaphrodite. The polymorphism hypothesis gives no explanation of the remarkable fact that, with the exception of Hydra, all the numerous descendants, often many thousand in number, of any particular planula, are of one sex; but we can readily understand how this might be the case if the fixed hydroid cormi have been produced as I suppose, for if the sexes are distinct in adult medusæ, the larva of any particular medusa must be either a male or a female, and there would be nothing strange in the fact that its gemmiparous offspring should resemble it in this respect.

Section VI.

A Review of the Literature on the Relation between the Hydra and the Medusa and on the Origin of Alternation of Generations.

The fundamental similarity between a hydra and a medusa is so obvious that it hardly seems necessary to dwell upon it, but the history of opinion upon the subject shows that this has been by no means uniform, although nearly all naturalists now agree that a single hydra is directly comparable or homologous with a single medusa, and that the various hydromedusæ are also directly comparable with each other; that both the hydra and the medusa are in that stage of individuality to designate which Haeckel's term "person" is now almost universally employed.

The general plan of structure is very much alike and the history of such forms as the Geryonidæ and Æginidæ, where the hydra-like larva becomes directly transformed into the adult, shows that a medusa is little more than a hydra with sense organs and a locomotor apparatus. The hydroids are not furnished with sense organs, although there is every reason to believe that the sense organs of the Narcomedusæ are modified tentacles, homologous with the solid tentacles of hydroids; and I know of only one writer who does not regard the cavity of the sub-umbrella of the medusa as the homologue of the space which lies on the oral side of the circlet of tentacles in such a hydroid as Eutima, Pl. 38, fig. 10. The mouth of the hydroid is homologous with the mouth of the medusa, and where this is mounted upon a proboscis or manubrium, this structure is directly comparable with the proboscis or pendent stomach of the medusa.

The ectoderm of the peristome of the hydroid, or the area included between the bases of the tentacles, is homologous with the ectoderm of the sub-umbrella and proboscis of the medusa; while the convex dorsal or aboral surface of the hydroid corresponds to the convex ex-umbrella of the medusa.

The oral tentacles of such a hydroid as Tubularia or Pennaria are to be compared with those of Margelis and I regard them as strictly homologous structures, while the zone which carries the circlet of tentacles of the Campanularian hydroids, or the aboral tentacles of Pennaria, is homologous with the bell margin of the medusa with its tentacles. The velum is not represented by any distinct hydroidean structure.

The digestive cavity of the medusa with its tubes or pouches is quite different from that of a hydroid, although the history of the origin of these parts in medusa-buds, or in the egg-embryo of Liriope or in Cunina, shows that the union of the ex-umbral and sub-umbral layers of endoderm has converted the peripheral portion of the simple digestive cavity of the hydroid into radial canals or pouches arranged around the central stomach of the medusa, which therefore does not correspond to the whole stomach of the hydroid, but only to its axial or central portion, while its peripheral portion is homologous with the canal system of the medusa. For a more extended statement of the subject see Koch (38) and Haeckel (78).

There can be no doubt that this, the generally accepted view, is correct, and the fact that the hydra-larva of the Trachomedusæ and Narcomedusæ becomes directly converted into a medusa, furnishes very direct and conclusive proof. I doubt, however, whether it could be so satisfactorily established if we were not acquainted with these forms; for many of the phenomena in the life of the Antho- and Leptomedusæ which are urged in proof of it are in themselves inconclusive. The retrograde metamorphosis, which according to Van Beneden (8), Hinks (33), Allman (6) and Merejkowsky (50) often results in the conversion of a medusa into a hydra-like organism, through the disappearance of the umbrella and the return to a sessile habit, seems to show that the two forms are mutually convertible; but Merejkowsky confirms Van Beneden's statement that in these cases of degeneration the resemblance to a hydra is entirely superficial.

The fact that the chymiferous tubes of a medusa-bud are formed by the development of areas of adhesion in the lateral portions of a digestive cavity which is at first continuous like the stomach of a hydra, is often adduced as evidence of fundamental similarity, but there is no reason for believing that the ontogenetic history of developing buds repeats the phylogenetic record. The history of Cunina and Liriope shows that the peristome of the hydra is the sub-umbrella of the medusa, and if bud-ontogeny were a recapitulation of phylogeny, we should expect the sub-umbrella of a budding medusa to arise as it does in Cunina; but we find, on the contrary, that in the medusa-buds of all the Campanularians and Tubularians, as well as in the Siphonophores, it originates as a bud-nucleus, *Knospungskern*, which gives rise by splitting, before the mouth is formed, to the sub-umbrella, which has at first no opening to the exterior. It is therefore unsafe to [illegible] any of the evidence furnished by bud-embryos; but the evidence from egg-embryology is not open to this doubt, for in all cases where there is no reason to suspect secondary modification, we may safely regard this as a recapitulation of phylogeny; and the [illegible] of those few medusæ which develop directly from the egg is therefore of the [illegible] importance as a basis for comparison of the medusa with the hydra.

In [illegible] egg-embryos, the "bud-nucleus" is absent, the mouth appears before the [illegible] its appearance and this is never closed but is formed by the folding [illegible] the chymiferous tubes are formed by the modification of a simple di[illegible] we should expect if the hydra and the medusa are representatives of the [illegible] fundamental type.

So far as I am aware, only one modern writer has advocated any other homology between the two forms than the one which I have stated. Ray Lankester has proposed (45) to homologize the sub-umbrella of a hydromedusa with the stomodæum of Anthozoa, Ctenophora and other Metazoa, basing this view upon the unproved and very improbable hypothesis that the young specimens of Limnocodium which he has described are egg-embryos. He does not state his view very clearly, but he must either believe that those Metazoa which are furnished with a stomadæum are the modified descendants of a form like an adult medusa, or else he must believe that the young Limnocodium represents the ancestral condition of the medusæ, and that the presence of a bell cavity is a very old characteristic. If he intends to advocate the latter view, it is plain that he cannot regard the medusa as an ordinary hydroid specialized for locomotion.

Many authors who have fully recognized the close similarity between the hydra and the medusa, and some who have been among the most important contributors to our knowledge of the subject, have nevertheless held that a medusa is not equivalent to a single hydra, but to a polymorphic hydroid community; that a medusa is not a person but a cormus.

This view has long been a favorite one, and it appears in many forms in the literature of the subject. The following extracts from my notes will serve to show how frequently it has been advanced, although I do not believe that the writers quoted are all who might be referred to. In 1854 W. Thompson compared the reproductive process of hydroids to that of plants and pointed out the resemblance between a medusa and a flower (59), and in 1860 Jäger (35) enlarged upon this familiar comparison and attempted to show that the medusa bears the same relation to the hydroid colony that the flower does to the plant, not only in position and in its reproductive function, but in its ultimate morphological structure also. He says it is made up, like the flower, of several circlets of individuals; that the tentacles, sense-organs, reproductive organs, etc., are all morphological individuals; that the swim-bells of Siphonophores are sterile flowers; that the medusa-buds of Hydractinia are flowers without calyces and that alternation of generations should more properly be called "*anthogenesis*."

In 1856 Wright advanced the opinion (63) that a veiled medusa is to be compared with a polymorphic hydroid community like Hydractinia, which he regards as a single person, not a cormus; that the umbrella is homologous with the flat, spreading root of Hydractinia, its chymiferous tubes with the canals of the root; that the stomach of the medusa is a nutritive hydranth, its tentacles spiral zooids, its reproductive organs medusa-buds, etc.

At a time when homology was not regarded as having any phylogenetic significance, there was little check upon such fancies as those of Jäger and Wright, but they are clearly of little more scientific value than Mörch's suggestion (53) that the Acalephs should be placed with the Mollusca on account of the imaginary resemblance between Lima and a medusa.

In 1856, Leuckart (47) in his account of the structure of a Trachomedusa, *Agalma Peronii*, figures and describes the reproductive organs. They form a circlet of eight hollow-stalked pouches, within the walls of which the eggs are developed; while their central chambers are outgrowths from the digestive cavity. The pouches are arranged in a circle around the base of the pendent stomach, and he calls attention to the marked resemblance between them and the medusa-buds, which are produced by many species in exactly the same situation. He therefore advances the hypothesis that the sexual pouches of Agalma are not organs but buds, which instead of becoming free sexual medusæ remain in a rudimentary or arrested condition; and, like the degraded medusa-buds of Hydractinia, give rise to ova or spermatozoa. He says "our *sexual organs* are therefore to be regarded as *sexual animals*, which, remaining sessile, form with the mother a polymorphic colony. The relation between these appendages and the medusa which carries them is in this species at bottom an alternation of generations." He is careful to state that he does not offer this as an interpretation of the reproductive organs of other species, and he says that while he is not prepared to decide whether the reproductive organs of Agalma are homologous with those of other medusæ, he inclines to the view that they are not.

Three years later Allman (3) advanced almost the same hypothesis, but in the form which he gives to it, the reproductive organs of Agalma and those of all the Anthomedusæ are simply organs, while the reproductive bodies of the Leptomedusæ are not organs but persons.

The fact that Leuckart first advanced the hypothesis as an explanation of the reproductive organs of Agalma while Allman excludes Agalma and brings forward the hypothesis as an explanation of the nature of the reproductive organs of quite different forms, is in itself enough to raise a suspicion that the whole conception is unscientific and fanciful.

As Böhm has shown in his valuable paper on the Leptomedusæ of Helgoland (9) that there is no such resemblance between the various stages in the development of a medusa-bud and the stages in the development of the reproductive organs of a Leptomedusa as Allman's hypothesis requires, it seems unnecessary to give any other reasons for rejecting it. Although Allman has devoted a paper to the attempt to show that the Geryonidæ are blastochemes (6), the life-history of Liriope, as I have detailed it, is absolutely irreconcilable with the belief that it is a cormus, and the hypothesis is completely overthrown by the recent discovery (76) that in many cases, the ova of the Leptomedusæ arise in the proboscis and migrate along the radiating canals to the ovaries.

One of the oldest opinions upon the relation between the hydra and the medusa is the one which Huxley adopts (31), that the medusa is a free locomotor reproductive organ. This is almost the opposite of Allman's view, that the reproductive organs of a medusa are themselves persons, and that the medusa is in reality a community. Huxley says (31, p. 119). "A medusoid, though it feeds and maintains itself, is in a morphological sense simply the detached generative organ of the hydrosoma on which it is developed," and on p. 31. "Morphologically the swarm of medusæ thus set free from a hydrozoon are as much organs of the latter as the multitudinous pinnules of a Comatula, with their [illegible], are organs of the echinoderm."

The authors who have accepted this view have appealed to the fact that we have a [illegible] series of species which present all the intermediate stages between the simple [illegible] prominences of Hydra and the free sexual medusa of Turritopsis or Eutima. In Hydra the reproductive organ is simply a protrusion from the surface of the body; in [illegible] it is more prominent and it contains a stomach-like outgrowth from the digestive cavity of the hydroid; in Hydractinia this outgrowth is a true proboscis or manubrium, which projects into a sub-umbral, ectodermal chamber opening to the exterior, and gives rise to a peripheral chamber which corresponds to the canal system of medusae. In some species of Tubularia the peripheral chamber is not continuous, but is divided into four radiating canals and a circular canal, and in other species the opening of the umbrella is furnished with tentacles, so that we have all the characteristic structures of a locomotor medusa, although the medusa-buds of Tubularia are never set free, and serve simply to mature the eggs and embryos. In a closely related form, Ectopleura, the ova or spermatozoa are matured before the medusa is set free, as is the case in Tubularia, but the medusae of Ectopleura are nevertheless set free, and live for some time as swimming medusae, while in still other forms the reproductive elements are very immature at the time the medusa is set free, and are gradually developed and ripened during its swimming life.

The series of forms is so complete that we cannot doubt that there is a genetic relation between them, and that they are actually steps in a process of modification; and it at first seems natural to conclude that the simplest forms show us the first steps in this process, and the more complex forms the later stages, and that they therefore prove that the free locomotor medusa has been gradually evolved from the simple sexual organ; but we must remember that the process of modification may possibly have gone in the other direction, and that the simple reproductive buds of Hydractinia and Eudendrium may possibly be degraded medusae which have gradually become sessile and have lost, by successive slight modifications, their locomotor apparatus.

So far as I am aware, Koch (38) was the first to point out, in 1873, that this is not only possible, but that there are facts which compel us to believe that it is actually true, such as the homology between a medusa and a hydroid and the fact that the medusæ of widely separated hydroids are fundamentally alike, while closely related species of hydroids may give rise to sexual buds which are very different from each other. For example, the hydroid communities of Hydractinia and Podocoryne (Dysmorphora) are so much alike that they can be distinguished only by the most careful examination, but Hydractinia produces sessile medusa-buds without radiating canals or tentacles, while Podocoryne sets free perfect locomotor medusæ. A very similar case is presented by Tubularia with its sessile medusa-buds and Ectopleura with its free medusæ; and the medusa-buds of Tubularia are essentially like those of Hydractinia, while the free medusæ of Ectopleura and Dysmorphora (Podocoryne) are again very much alike. If we put these facts into tabular form, we shall have something like this:

1	Hydractinia	Sessile buds	Tubularia	3
2	Podocoryne	Medusæ	Ectopleura	4

1 and 2 are much more closely related to each other than to either 3 or 4, while 3 and 4 stand in a similar relation to each other; and, if we believe that medusæ have been produced by the gradual specialization of reproductive buds, we must believe that 2 has

been produced by the modification of 1, and 4 by the modification of 3, and that the locomotor habits of 2 and 4 have been independently acquired.

In these cases we have a pulsating, gelatinous bell, with sub-umbral muscles and a veil; a pendent stomach with ova or spermatozoa developed in its walls; four radial canals, a circular canal and hollow marginal tentacles; and the two medusæ are almost as much alike as the hydroids 1 and 2, or the hydroids 3 and 4. The chances are very greatly against the independent modification of the two forms along lines which are so perfectly parallel, and when we bear in mind that the hypothesis compels us to believe that this has taken place not in two but in many cases, the difficulty becomes a very great one; but, if we adopt the opposite hypothesis, and regard the medusa-bud as a degraded, sessile medusa, there is no such difficulty, for similar medusæ would give rise, by degradation and the loss of their locomotor apparatus, to similar medusa-buds. Then, too, if the medusa-buds are stages in the process which has led to the formation of free medusæ, we cannot account for the presence in buds which never became free, of structures which like the bell-cavity and velum are of functional importance only in the swimming medusæ, although we should expect these organs or their rudiments to be retained by medusæ which had lost their swimming habits and become sessile.

These and other facts have led most naturalists to believe with Koch that the medusæ are not specialized reproductive organs, but modified hydras, and that the sessile medusa-buds are degraded medusæ rather than stages in the evolution of medusæ. The life-history of Liriope seems to be totally irreconcilable with Huxley's view, for this would require us to believe that the egg here gives rise to nothing but a reproductive organ and that this process is continued generation after generation.

I think, therefore, that the facts justify the statement that our present knowledge of the subject disproves the view which Huxley advocates and that this view is now untenable. As a matter of fact, nearly all naturalists reject it in favor of the "polymorphism" hypothesis, which the student will find presented in the text-books of Gegenbaur and Balfour, but examination of the special literature will show that the various advocates of this hypothesis are by no means agreed as to the precise manner in which the two polymorphic forms, the hydra and the medusa, have been produced.

Balfour, for example (65), adopting essentially the views which had been brought forward many years before by Leuckart, says, "The chief interest of the occurrence of alternation of generations among the Hydromedusæ and Siphonophora is the fact that its origin can be traced to a division of labor in the colonial system of zooids so characteristic of these types. In the Hydromedusæ an interesting series of relations between alternation of generations and the division of the zooids into gonophores and trophosomes can be made out. In Hydra the generative and nutritive functions are united in the same individual. * * * A condition like that of Hydra in which the ovum directly gives rise to a form like its parent is no doubt the primitive one. * * * The relation of Hydra to the Tubularidæ and Campanularidæ may be best conceived by supposing that in Hydra-like forms the buds did not become detached so that a compound hydra became formed, and that at certain periods particular buds retained their primitive capacity of becoming detached and subsequently developed reproductive organs, while the ordinary buds lost the generative function. It would obviously be advantageous to the species that the detached buds with generative organs should be locomotive, so as to distribute the species as widely as possible, and such buds in connection with their free existence would naturally acquire a higher organization than their attached trophosomes. It is easy to see how, by a series of steps such as I have sketched out, a division of labor might take place, and it is obvious that the embryos produced by the highly organized gonophores would give rise to a fixed form from which the fixed colony would be budded. Thus an alternation of generations would be established as a necessary sequel to such division of labor." He goes on to state his belief that the sessile medusa-buds are degraded medusæ, and that the medusæ, which like Liriope develop directly from the egg, are forms in which the hydra stage has disappeared from the developmental cycle; and summing up his views he says that three types of development are presented by the Hydromedusæ.

1. No alternation of generations: permanent form a sexual hydra or hydra community. *Example:* Hydra.

2. Alternation of generations: hydroid stage fixed, medusa stage free. *Example:* most hydroids.

3. No alternation of generations: permanent form a sexual medusa. *Example:* Trachomedusæ.

But, in his explanation, which we have quoted, he recognizes the following six successive stages in the evolution of the Hydromedusæ.

1. Solitary hydra, no polymorphism, all buds detached, all persons sexual.

2. Community of sexual persons, giving rise also to detached buds which also become sexual persons.

3. Polymorphism, community of asexual nutritive persons, detaching buds which become sexual persons.

4. Same, detached sexual persons specialized as locomotor medusæ.

5. Polymorphic community consisting of nutritive asexual persons and sexual sessile medusæ-buds, or

6. Derived from 4, medusæ without a hydra stage.

Grobben (74) advocates a view which is very similar to that given by Balfour, and he believes that the alternation has been produced by the following series of steps:

1. Solitary hydroids, like Hydra.

2. Communities without polymorphism, each individual sexual, like Hydrella.

3. Communities, with polymorphism, with sexual and asexual persons, all sessile.

4. Same, with free reproductive persons.

5. Same, with free reproductive persons specialized as locomotor medusæ.

6. Same, with medusæ degraded to sessile reproductive buds.

7. Derived from 5, medusæ without a hydra stage.

While Balfour believes that certain members of the community first became free and afterwards became specialized for reproduction, Grobben believes that they became specialized for reproduction while sessile, and that the tendency to become free was afterwards acquired, but in other respects these two authors are in substantial agreement.

Hamann (32), however, adopts a somewhat different view and says that it was possible to believe that the alternation, or the origin of the medusa on the hydroid, came about through division of labor, so long as it was supposed that the reproductive elements originate in the medusae; but the discovery that the eggs, in many cases, originate in the cœnosarc of the hydroid and migrate into the medusa-buds, shows, he says, that this is not the true view, and he advances another which was suggested to him in conversation with Weismann. Starting with a community in which the reproductive elements may originate in every part, he supposes that certain persons were set free from the stock as in Hydra or in Tiarella, and that the persons thus set free were at first driven about by wind and tide, obtaining their food by the use of their tentacles; that they were simply floating hydras. Those which became adapted to this new life would, retaining their power to produce eggs, give rise to fixed communities, in which locomotor persons would be set free earlier and earlier, until finally the reproductive function would become restricted to the free stage which would gradually acquire a locomotor apparatus and thus become a medusa.

These various opinions which are selected from a great number which might be quoted show that the "polymorphism" hypothesis, which is the one most generally accepted, is itself polymorphic and that authorities are far from an agreement as to the precise form which it should take and this lack of agreement is in itself sufficient to excite a suspicion that it may be merely an hypothesis unsupported by proof.

All these authors agree, however, in the opinion that the reason for the evolution of the locomotor medusa is the advantage which comes from the distribution of the sexual elements and embryos, and the analogy of the polymorphic hydroids seems at first sight to be a reason for believing that the medusa has originated according to the law of division of labor. The hydroid blastostyle is undoubtedly a hydranth which has in this way lost its nutritive function, and has become exclusively a reproductive zooid, while the ordinary hydranths have lost their reproductive function and have become simply nutritive persons, and there is every reason for believing that the polymorphism of such a hydroid as Hydractinia has been brought about by division of labor; but is there any real analogy between a blastostyle and a medusa? The medusa is very far from being, like the blastostyle, a reproductive zooid. The blastostyle has no mouth but the medusa is a highly voracious animal, furnished with organs for perceiving and capturing its prey, and with highly developed digestive organs. There is nothing in the structure of a medusa to indicate that it is a reproductive zooid. It is true that in a few Tubularians such as the Eucopella, recently described by Lendenfeld, or in Corymorpha, it is simplified in structure and is little more than a locomotor reproductive pouch; but these cases are probably the result of recent modification, and the typical medusa has all the characteristics of a perfect adult animal with all the powers necessary for a complete life, and in many cases it produces other medusae by budding. There is certainly nothing in its structure to indicate that it has like a blastostyle originated by division of labor. It does not show any tendency to lose its nutritive function, and its locomotor and sensory functions are not lost, as we should expect them to be in a zooid specialized for reproduction, but they are, on the contrary, much more highly developed than they are in the nutritive hydra. It is true that the hydranths have, as the theory requires, no reproductive function, but this is no more than we should expect, if the hydra is a medusa larva.

Balfour says that "it would obviously be advantageous for the species that the detached buds with generative organs should be locomotive, so as to distribute the species as widely as possible, and such buds in connection with their free existence would naturally acquire a higher organization than the attached trophosomes." It seems at first sight as if this must be true, but more careful examination will give us many reasons for questioning whether the high organization of the medusa has been acquired for the purpose of distributing the species, rather than for the benefit of the individual. We know that, in many species, of all the great groups of hydroids, the medusæ have become degraded into sessile gonophores which have lost their locomotor power, and in many cases all their complicated organization as well. This degradation must be for the advantage of the species, and in view of its prevalence I think we must hesitate to believe that the production of free reproductive zooids would be for the good of the species, and that after such free zooids were produced, they might be expected to acquire a complicated organization and highly specialized locomotor and sensory organs. We know that changes in the opposite direction have been to the advantage of the species, since they have been preserved, and if sessile gonophores are so useful that free medusæ have been degraded into sessile gonophores, there is no *a priori* reason for believing that it would be to the advantage of the species for reproductive zooids to become locomotor. The distribution of the species is well provided for in the swimming planula and the habits of the medusa often carry it very far from any proper habitat for the hydra, and as a matter of fact, genera and species without free medusæ are as widely distributed as those in which the medusa is a perfect swimming organism. Eudendrium and Cordylophora have no means of dispersal except the cilia of the planula, yet Cordylophora is found on both sides of the Atlantic and from Boston to Baltimore, and Eudendrium is found all over the world. Turritopsis is an extremely active medusa, living in the open sea, and it is often swept by the gulf stream as far north as Cape Cod, yet its hydra has been found nowhere except upon the North Carolina coast.

I think that we may safely conclude that while the view that the complex structure of the medusa has been acquired as a means for distributing the species seems at first sight to be very plausible, more careful examination renders it probable that this is not the case, but that the purpose of the organization of the medusa is to enable it to live out its own life; that it has been acquired and preserved on account of its direct benefit, rather than from any indirect advantage to the species as a whole.

In 1871 Koch advanced an hypothesis which escapes this difficulty, since he believes that the medusa stage has been acquired to prevent self-fertilization rather than to secure the distribution of the species, and his hypothesis is therefore more satisfactory than those which have been noticed.

He says (38) that the ancestral form was a hydra, with solid scattered tentacles, reproducing both sexually and asexually, and that in some species the new buds were set free as in Hydra, while in others they remained attached and formed communities.

Those which were set free either fastened themselves like Hydra, or they remained floating in the water, and gradually became adapted to a free life, and thus furnished the incentive for the formation of the medusa, which as Koch clearly shows, as Claperède had also shown years before (13), is not essentially different from such a hydroid as Tubularia. In a species with both sessile and swimming persons, the latter, if both were sexually mature, would be much less likely to interbreed closely than the former, and the sessile forms would therefore gradually lose the power of sexual reproduction, while the swimming forms would become the reproductive persons of the species. This specialization of the reproductive function would tend to secure cross-fertilization and it would therefore become established on account of this advantage.

He then supposes that some of these hydroids with free medusæ became established in places where the locomotor medusæ were exposed to the danger of being swept out to sea, away from proper localities for the attachment and growth of the sessile hydras, before these were born. Natural selection would, under such circumstances, lead to the preservation and perpetuation of those medusæ which reproduced their young very early in their own life, and we should thus gradually obtain medusæ which became sexually mature before they were detached; and as these medusæ would derive no advantage from a locomotor life they would gradually become converted into sessile medusa-buds.

According to Leuckart, Gegenbaur, Hamann, Balfour and others, the locomotor organs have been acquired for the purpose of distributing the species, and the free persons first became the sexual members of the species, and then became locomotor, while Koch believes that the locomotor life has not been acquired for the purpose of distributing the species; and that the free persons became locomotor medusæ before they became specialized for reproduction, and that the reason for this specialization was not the need for distributing the species, but the advantage of crossing. So far as simple plausibility goes, this hypothesis is certainly a little more satisfactory than any of the others, but the test of the truth of an hypothesis is an appeal to fact, rather than its neatness.

While the various writers who have advocated the hypothesis of polymorphism differ so greatly in their accounts of the process by which the medusa has been evolved, by the specialization of persons detached from a hydroid community, the "proofs" which they advance in support of the belief that it has originated by such specialization are essentially the same. As the first step in the argument, they point out the homology between the hydra and the medusa, and justly claim that this proves that both are modifications of some common type, and they then proceed to make either on words or by implication the farther assumption that this type must have been either a member of a hydroid community or a medusa. Thus Koch says, "in the attempt to study the relation between the hydra and the medusa in the light of the theory of descent, we have to decide between two hypotheses: *first*, that the medusa is primitive and that the hydroids are only larvæ [illegible] have been independently modified, or *second*, that the hydroids are primitive and [illegible] have been derived from them. The fact that the hydra bears a close [illegible] to many other organisms, such as sponges and corals, while the medusa [illegible] resemblance to other groups, leads us to reject the first hypothesis and to [illegible] second alternative." If we were compelled to accept one or the other of these [illegible] is no doubt that this reasoning would be of great weight, but it is quite possible that neither hypothesis may be correct, and that the primitive form may have been neither a sessile hydra nor a highly specialized medusa, but something midway between; for example, a ciliated locomotor organism with simple hydra-like structure. But overlooking this third alternative, and deciding that the homology between the hydra and the medusa can only be explained on the hypothesis that one has been derived from the other, they go on to show, quite correctly, that the view that the medusæ have been produced by the gradual specialization of medusa-buds, or medusiform gonophores, leads us to a series of untenable positions, and that we are compelled to believe that the medusa-buds are degraded medusæ. They therefore conclude that the medusæ must have originated as modified hydroid persons, which have become adapted to a swimming life, and have assumed the function of sexual reproduction, which has at the same time been lost by the sessile unmodified hydras.

In the absence of all direct evidence, this reasoning could be termed "proof" only by showing that we are compelled to accept one of the two hypotheses, and a very great step was made towards the solution of the question when Böhm showed in 1878 (9, p. 153) that the primitive form may have been intermediate between medusæ and hydroids, and that both these forms may have been developed from this common form in two divergent directions.

Böhm points out that the long path from the slightly specialized sessile hydra to the highly complex swimming medusa is greatly shortened by the assumption that they are both derived from an intermediate form; and on p. 171 he says that an additional reason for the belief in such a form is to be found in the fact that in certain families, as in the Eucopidæ, the very simply organized medusæ are so much alike that it is difficult to find any distinctive specific characters, although the hydroids are often very different from each other, thus proving that they have diverged more than the medusæ.

As he justly remarks, it is much more difficult to understand the origin of locomotor medusæ by the modification of sessile polyps or the reverse, than it is to understand the origin of both from an intermediate form which has served as a basis for two lines of modification; and he therefore believes that both the hydra and the medusa are descended from a free, solitary hydra-like organism with solid tentacles and with lasso-cells, which were peculiarly abundant at the tips of the tentacles. The life-history of Liriope, as I have described it, furnishes us with a stage of development which is exactly like Böhm's hypothetical form in every particular, except that its endoderm and ectoderm are separated from each other by a thick gelatinous layer. The ciliated, tentaculated larvæ of Æginopsis and Ægineta which Metschnikoff has figured (51), and the Cunina larvæ shown in Plate 13 of this paper, are also free hydra-like larvæ which become directly converted into medusæ without the intervention of a sessile "nurse" stage, and without metagenesis. Böhm himself does not refer to the Trachomedusæ or the Narcomedusæ in this connection, although he calls attention on p. 162 to the fact that the actinula of Tubularia is an example of the persistent retention of this locomotor ancestral stage.

He says very little about the actinula larva, however, and he selects Eleutheria as the best modern representative of the hypothetical ancestral form, and treats of its structure at considerable length. This selection seems an unfortunate one to me, for Eleutheria itself has an alternation of generations, and the Eleutheria stage does not occur at the beginning of the life-history, but at the end. The Cladonemadæ are simply ordinary Anthomedusæ, with a tubularian hydra-stage and medusæ produced by budding; and it may be due to the unfortunate selection of Eleutheria as an illustration, that Böhm's view, the correctness of which seems to me to be proved by the occurrence of a locomotor solitary larval hydra stage in the Trachomedusæ, has attracted so little attention.

His contribution to the subject is a decided advance beyond the views which we have noted, for he shows clearly that we are not compelled to choose between the two alternatives which seemed to the other writers to be the only ones, but that the third, viz., that the primitive form was not a sessile community but a locomotor person, has much to commend it: and that we are not compelled to believe with Kleinenberg (75, p. 33) that the alternation is primitive, but that it may have been gradually and secondarily acquired (9, p. 159). Having thus cut himself partially loose from tradition, so far as the antiquity of the nurse stage in the history of the medusæ is concerned, he rests satisfied with the old explanation in other particulars, and states, on p. 159, his belief that the divergence from his stem-form, which resulted in the production of the sessile hydra and the locomotor medusa, was brought about by division of labor and polymorphism; he further says that the locomotor stem-forms multiplied asexually, and thus gave rise to cormi, and that some of the persons of the cormus then became gradually specialized for nutrition, and were thus converted into sessile hydras, while other persons became specialized for reproduction, and were gradually converted into true medusæ.

Böhm's paper was published in 1878, and in the same year Claus (15) also showed that the hydra and the medusa are modifications of a common type, of which the actinula is the living representative (p. 50), and in his Grundzüge der Zoologie, 1880, he advances an explanation of the origin of the alternation between the hydra generation and the medusa generation, which, so far as I am aware, had never before received attention, although there can, I think, be no doubt that it is the true one.

He discusses the subject very briefly and simply says, on p. 62, that alternation of generations may be between two stages with similar organization, or it may be *between the larva and the adult as in the Medusa*. He goes on to point out that we must therefore recognize two distinct kinds of alternation which have originated genetically in two different ways, and have different explanations. We must believe that the second sort of metagenesis, that which resembles metamorphosis, has originated, in most cases, through the retention by the larva of the power to multiply asexually at a stage of development at which, while it may be more or less subject to secondary modification, corresponds to a remote ancestral stage in the evolution of the species; and that a larva-like [illegible] stands in the same genetic relation as the larva itself, but the original stem-form, [illegible] is now represented by the larva, had in addition to the power of sexual reproduction, which is now restricted to the highly modified adult, the power of asexual multiplication by budding, which has been preserved by the larva in the course of the phylogenetic [illegible] of the species. On pp. 245–246 he also calls attention to the fact that the [illegible] of [illegible] is a modern representative of the ancestral stem-form, and [illegible] is a locomotor ciliated larva which is neither a hydroid nor a medusa, [illegible] type which might be modified in either direction.

In his paper on Tetrapteron (16) he says that he has expressed his view of the manner in which alternation originated among the medusae in his paper on Halistemma (15), but I am unable to find it there, or to find any statement of his view earlier than 1880.

A recent writer in Nature (28) states, p. 69, that Claus supports the view originally formulated by Leuckart, that alternation of generations has originated among the medusae through polymorphism, rather than through a modification of metamorphosis, but he gives no references in support of his statement, which is probably an error like many others which occur in the paper.

In 1883 I published a paper in which I gave a very brief explanation of the origin of alternation in the medusae. My view is identical with that which I have quoted from Claus, although I reached it independently and in ignorance of Bohm's and Claus' writings on the subject. The paper is a short abstract without illustrations, but my conclusion was based upon the life-history of the Narcomedusae and Trachomedusae, which seem to me to furnish much more conclusive proof than any which these writers bring forward.

The statement is as follows: "It is hardly possible that the form of development which we now find in most of the Hydromedusae can bear any close resemblance to their primitive life-history, and there are many reasons for believing that alternation of generations has gradually arisen through the modification of 'metamorphosis.' In Cunina we seem to have the ancestral form of development: a direct metamorphosis without alternation * * * The larva of Cunina is a hydra with the power of asexual multiplication; but, instead of giving rise to medusa-buds, like an ordinary hydroid, it becomes directly converted into a medusa by a process of metamorphosis: it is a true larva and not an asexual generation, although the occurrence of asexual reproduction renders the gap between this form of development and true alternation very slight indeed.

In Cunina we have a series of this kind:

Egg
|
Larva – Larva – Larva
| | |
Adult Adult Adult

If the larva which is produced from the egg were to remain permanently in the hydra stage we should have a series like this

Egg
|
Hydra – Hydra – Hydra
| |
Medusa – Medusa

and such a history would be a true alternation." (12).

A few months later, March 1884, Fewkes published a paper (19) in which he says "That exceptional form of development, called alternation of generations, which exists in the fixed hydroids may be regarded as the irregular not the normal method. It is an adaptation resulting from peculiar circumstances and a departure from a rule in one di-

... of the Siphonophores is in another. The Cunina colonies have resemblances with both fixed hydroids and Siphonophora, but have not departed as widely as either from the normal method in their older larval and adult condition" (p. 305).

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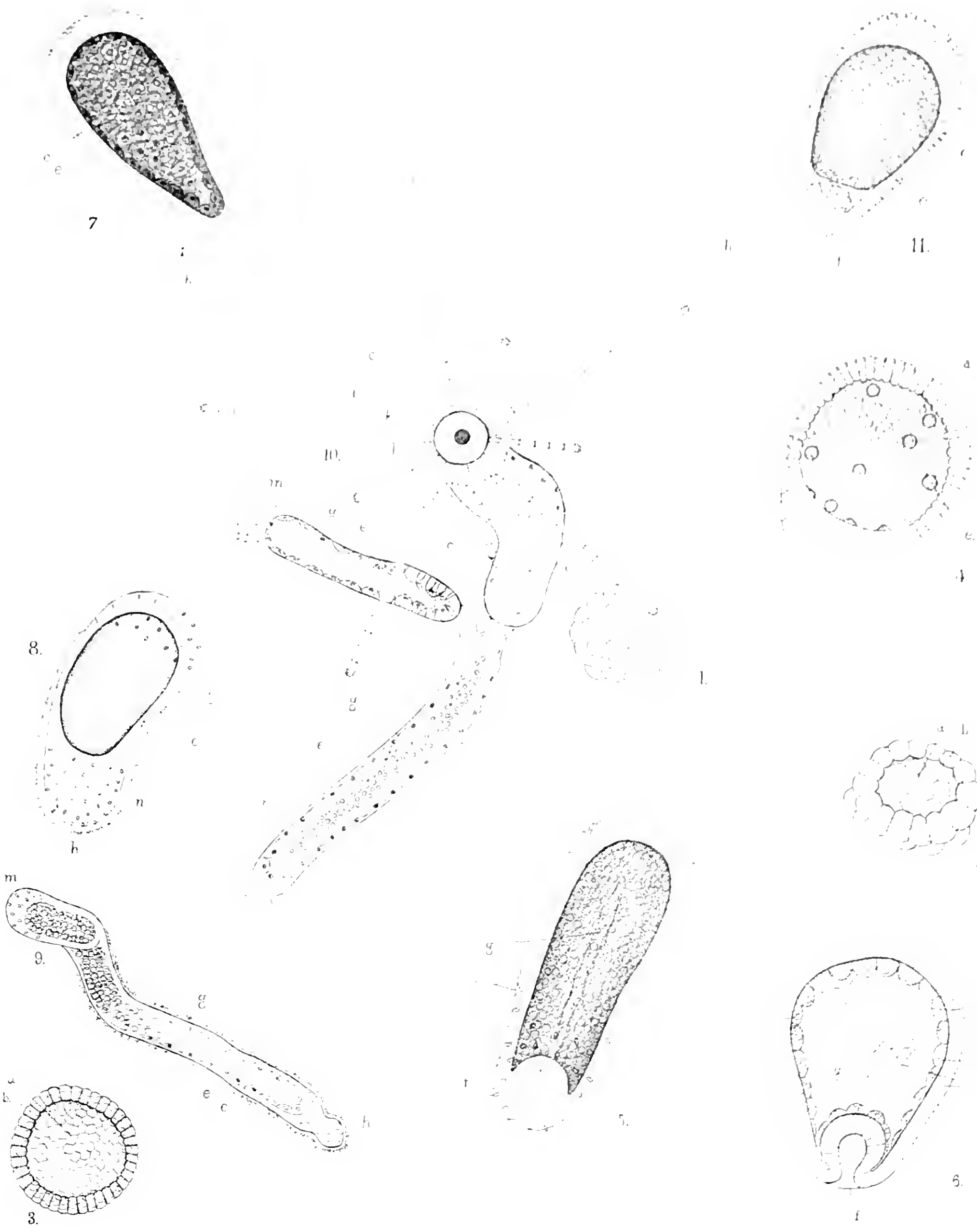
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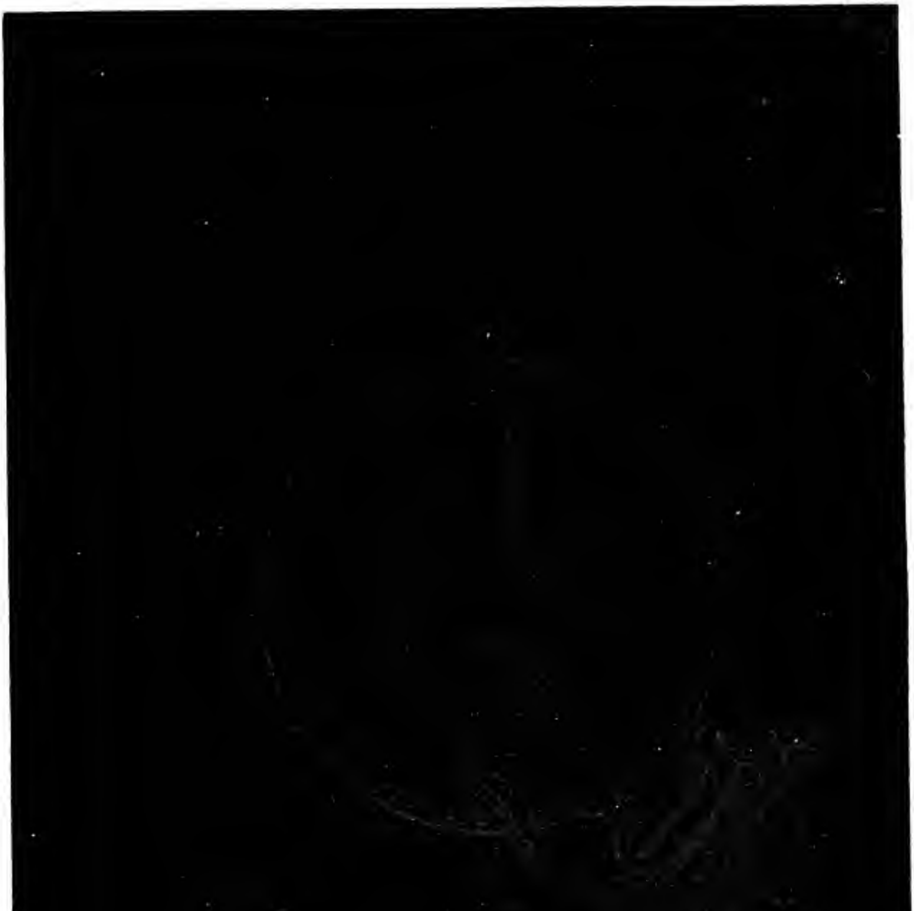

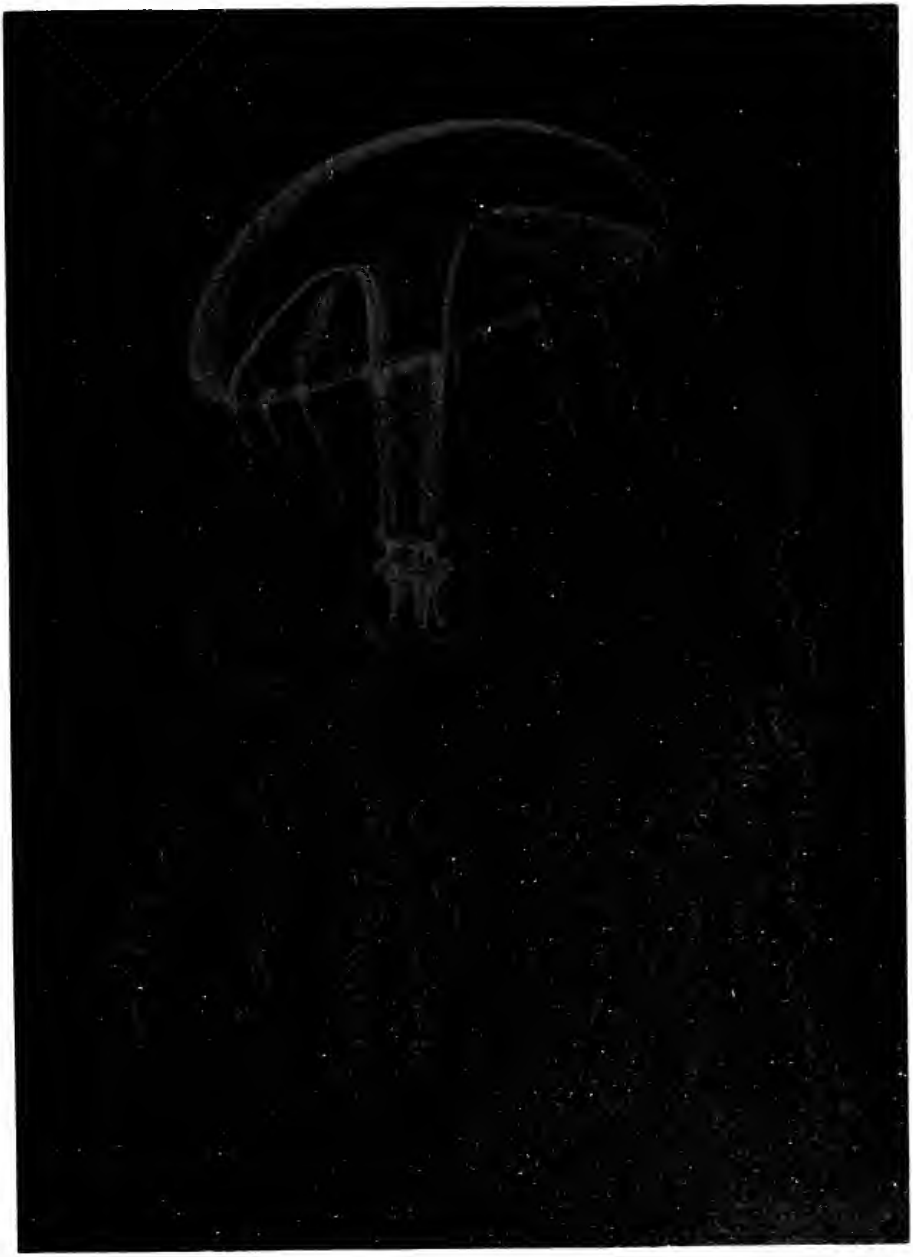

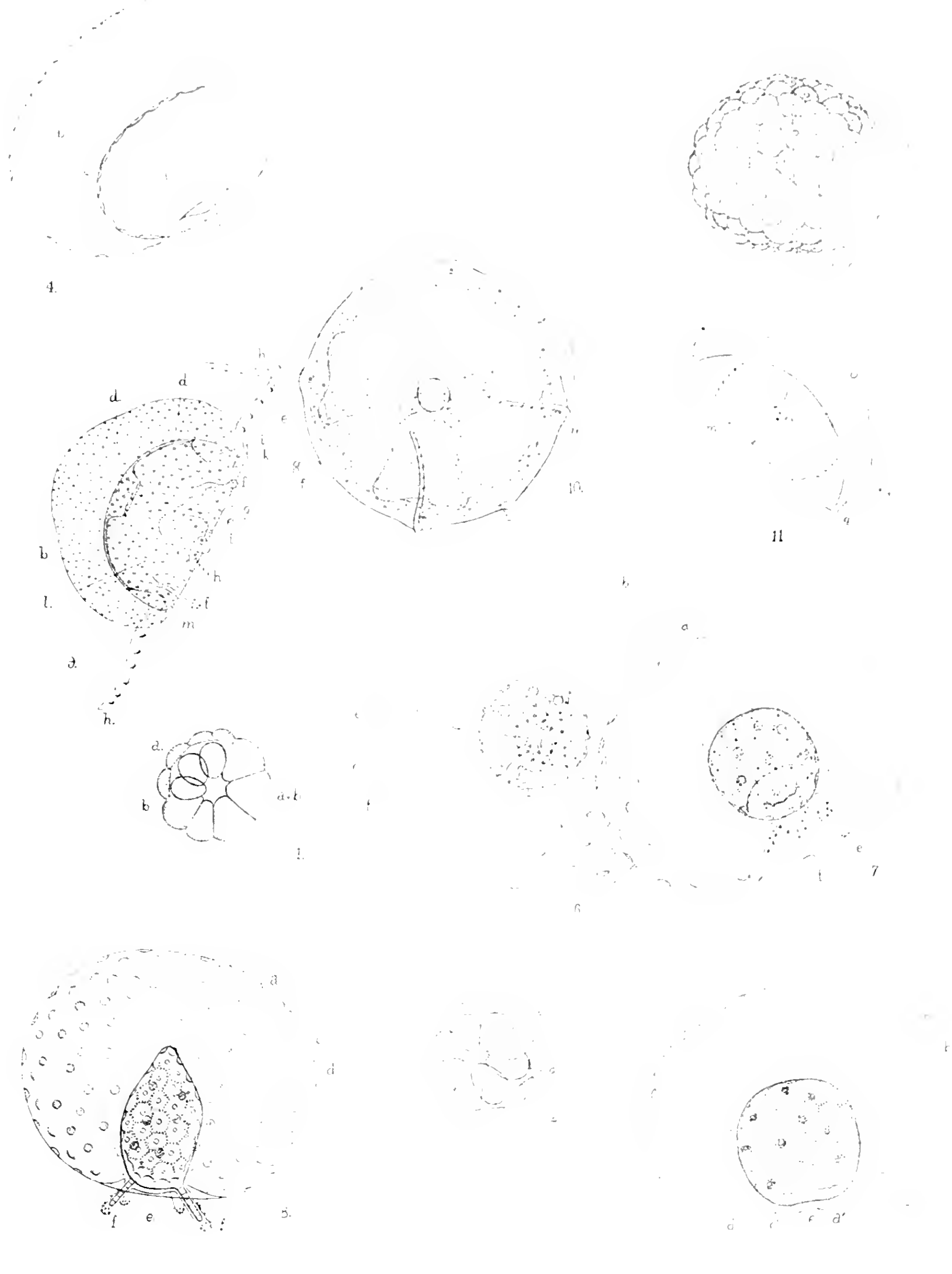

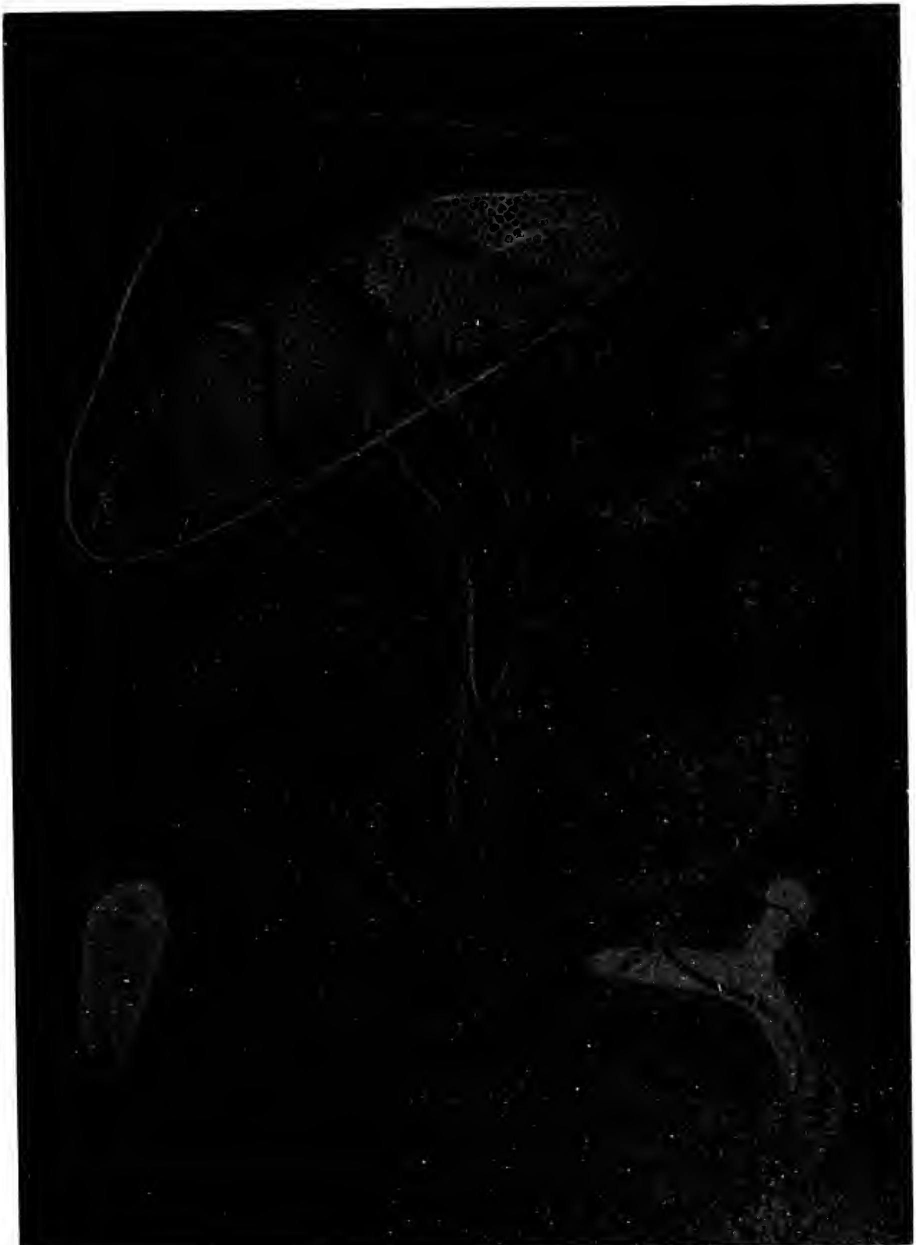

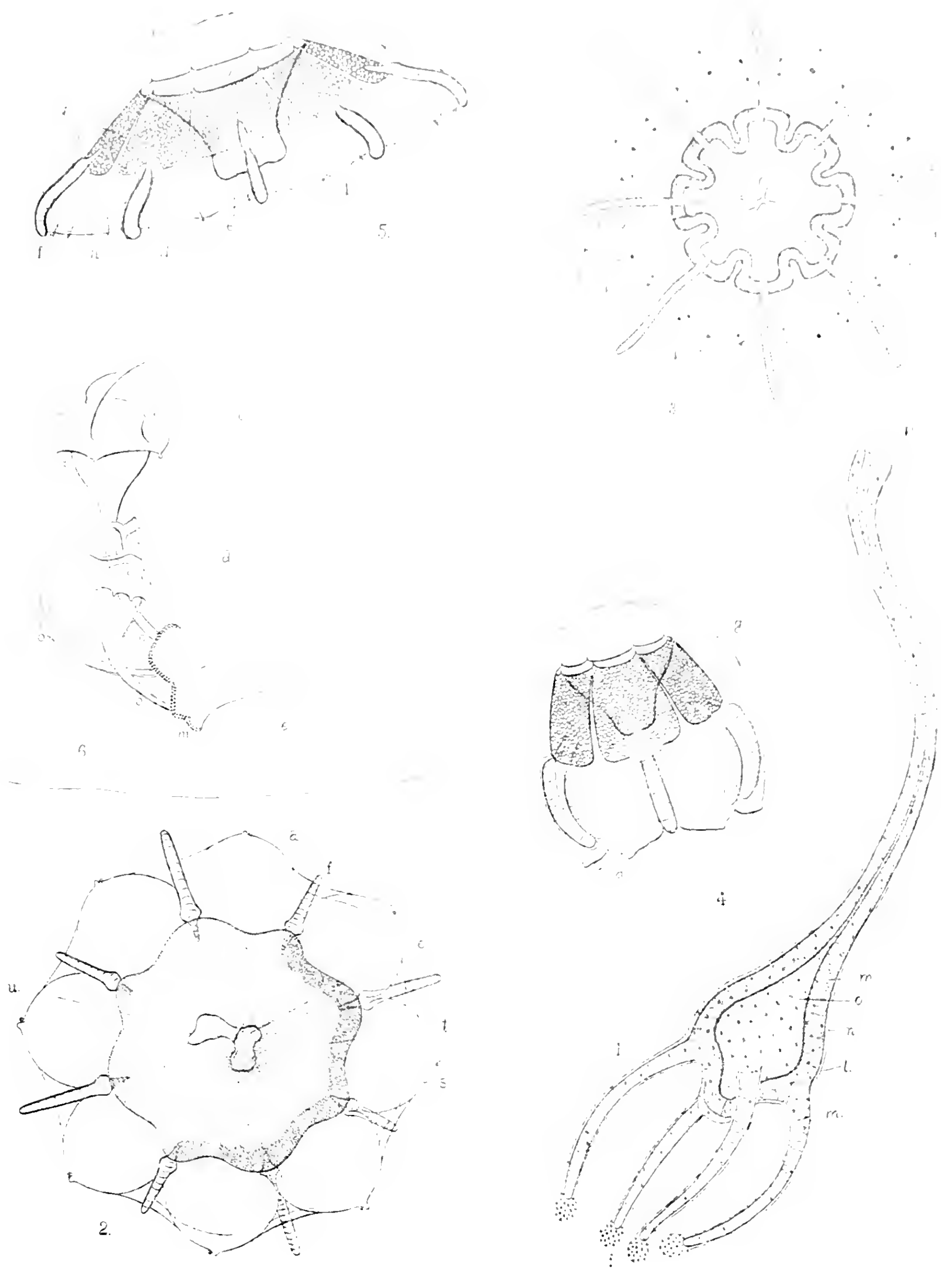
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XV. The oldest known Insect-larva, Mormolucoides articulatus, from the Connecticut River Rocks.

By Samuel H. Scudder.

Read February 6, 1884.

Professor Edward Hitchcock, who published so extensively upon the footprints found in the sandstones of the Connecticut River was the first to make known the presence in the triassic shales at Turner's Falls, Mass., of insect remains.[1] These he first mentioned in his report on fossil footmarks published by the state in 1858, giving illustrations upon one of his plates, which are too obscure to be of any value. Judging the creature to be a crustacean, he sent specimens to Prof. J. D. Dana of New Haven, who, in a letter published in this volume by Professor Hitchcock, considered it to be "probably a larve of a neuropterous insect," and sent to Hitchcock the cut we here reproduce, in which he regards *A* as the head, *B* to *C* as thoracic, and *C* to *D*, abdominal segments. This, reduced, is the figure given in Dana's Manual of Geology.

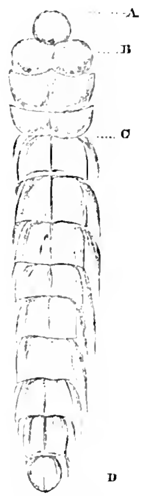


Fig. 1. Mormolucoides articulatus Hitchcock.

Some years after this, the late Dr. J. L. Leconte, having expressed the opinion from an examination of the figures alone, that Professor Dana was correct in his judgment of the neuropterous character of these remains, and having further referred them more definitely to the Ephemeridae, Dr. Hitchcock, who never lost the opportunity of changing the name of a fossil, if he thought he could thereby indicate more closely its affinities, proposed that the name of *Mormolucoides articulatus*, he had at first given it, should be altered to *Palephemera mediaeva*. The first name, being in no sense misleading, must, of course, be retained, and indeed fortunately, since this is not the end of the opinions which have been held (and may perhaps yet be held) regarding it.

Having an opportunity some years since, of studying a slab lent me by Prof. O. C. Marsh, containing twenty or thirty individuals, and of comparing them with others in the Museum of the Boston Society of Natural History, I published my views of the structure and relationship of this fossil larva in the Geological Magazine of London, in which I came to the conclusion that they were coleopterous larvae, and suggested that they "remind one of some Cebrionidae," but the only larva of that group whose history is known "lives on the roots of plants and would not be likely to occur in

[1] *Mormolucoides articulatus* Hitchcock, Ichnol. N. Engl., pp. 7–8, fig.; Pl. 7, figs. 3–4.—Dana, Ibid.—Scudder, Proc. Bost. Soc. Nat. Hist. xi, p. 110; Id., Geol. Mag., v, pp. 218–20.

Palephemera mediaeva Hitchcock, Amer. Journ. Sc., [2] xxxiii, p. 452.—Packard, Bull. Essex Inst., iii, p. 1.

such a deposit as that in which these remains were found." In this communication, finding among the specimens I examined none with any lateral appendages, I concluded that the figures which had been given were inaccurate in that particular, a conclusion based, as will be seen, on insufficient material.

A few years later, Dr. A. S. Packard published a short note upon them, in which he expressed the opinion that they were "aquatic coleopterous larvae, belonging perhaps near the family Heteroceridae."

It will thus be seen that some difference of opinion has been expressed concerning the affinities of these fossils, though they have uniformly been considered larvae, and as belonging either to Neuroptera or Coleoptera.

Having recently been able through the kindness of Professors Emerson and Hitchcock to examine the considerable collection of these remains in the cabinets of Amherst College, and by favor of Professor Marsh to study all the specimens in the Yale Museum, I have examined with care some hundreds of these larvae, and reviewed the whole subject anew. Notwithstanding the considerable differences which show themselves, I am strongly convinced that all the specimens I have studied belong to a single species, differing somewhat in structure from what I formerly believed, and whose affinities are pretty clearly different from what I formerly supposed, several new features, not before observed, being now apparent. This point, however, will be discussed after the structure has been set forth in full.

The body is composed of thirteen apparent segments, of which the head forms one, and three are differentiated, sometimes very obscurely, as thoracic. The statement that the head forms but a single segment is at variance with my former conclusion, for the two segments of the description then given by me form together what I now look upon as the head. There are doubtless a good many specimens which lend color to my former conclusion, and I reproduce upon the plate (fig. 3), a copy of a drawing made fifteen or more years ago of what I then considered the first three segments of the body. A similar development of the first segment may be seen in fig. 13, and to a much less extent in fig. 9. Whether these lateral anterior lobes of the head, always separated from it by a more or less marked suture, are inferior appendages showing only when projected forward, can hardly be determined, but this seems the most probable explanation. The decided differentiation of the thoracic segments in certain individuals (see figs. 1, 5, 14 for example) leaves no room for doubt that the smaller segment in front of them, usually single, at other times apparently double, represents the head.

The head then is a rounded segment, usually a little broader at base than in the middle (see especially figs. 12, 16) and slightly broader than long, the front well rounded. It is generally about as large as the hindmost segment of the body, but occasionally is larger than it where the final segment appears but partially extended, and in a few instances is much larger; it is then also out of all due proportion to the segments behind it, as in fig. 10, where it does not appear to be crushed and unnaturally expanded, but [illegible] as if the lower appendages of the head, forming in other cases the protruded an[illegible]es, had been laterally spread out and lay beside the head, of which, as in the [illegible], seem at first sight to form an integral part. That this is the correct view [illegible] probable because, when the surface is not absolutely flat (as may be the case in any fossil insect, no matter how highly irregular its surface may have been in life), the head is provided with lateral bosses, which may be partly explained as due to the underlying appendages; for when these supposed appendages are thrust forward and form the anterior lateral lobes, it is these lobes which are embossed, as described in my previous paper; while when, as in fig. 10, they are supposed to lie outside the lateral limits of the head, the protuberances are still found connected with them. What appendages these lobes may represent it would be difficult to say. One would more naturally expect such evidently corneous organs, forming bosses even where they are separated from the head, to be mandibles, but their broad and rounded shape gives no clear evidence of their use in such a way; and in such a flattened larva it could not be supposed that they formed a vertical fang, the crushing of which, from above downward, would bring all the chitinous portion together in a mass, and so produce a boss upon the stone.

The three thoracic segments are almost invariably larger, generally considerably broader than the others, and are often distinctly differentiated as a separate region, both by their breadth, greater than that of the uniform segment behind, as well as by the slight forward inclination of their sides. This appears clearly in fig. 5, but is generally less marked than there by the smallness of the hindmost thoracic segment, which is not often broader than the following abdominal segment, as in figs. 5 and 11. Usually also the middle thoracic is larger than the front thoracic segment, so that their relative size is II, I, III (see figs. 1, 11, 12, 14) but not infrequently the front one is the largest, as in figs. 5, 6, 10, and there are some cases where the broadest part of the body is behind the thoracic segments, and the order of breadth in the thoracic segments is III, II, I. In these cases, as in figs. 4, 7, 13 and particularly 9, the whole aspect of the insect is changed, and yet a careful study of the specimens leads one to the conviction that all belong to a single species. In some, of which fig. 5 may be taken as an extreme type, we are reminded, in form, of the larva of a longicorn beetle, while the other extreme, as in fig. 9, recalls rather some of the Silphidae. What may be looked upon as the average or normal thoracic segment, is about three times as broad as long, subquadrate, with very slightly concave front margin, and a little more distinctly convex hind margin, the sides well rounded and the hinder angles more broadly rounded off than the front lateral angles, giving a slight sublunate form to the entire segment. These segments are further marked by more or less distinct lateral marks, usually impressed, either angular (figs. 5, 14) or rounded (figs. 1, 10, 15), which are the only indications, if such they are, of appendages. I had thought they might be taken for the marks of very short legs, and perhaps they can; but the figures given by Schiödte of the larvae of the coleopterous genera Necrophorus, Anisotoma and Agathidium, where similar marks are purely sculptural, leave me in doubt. Every one must have seen in nature similar marks on longicorn larvae, but these are more generally mesially disposed, and do not, as here, reach so distant a point from the middle line. Whatever they are, there is nothing else on a single specimen examined by me—many hundreds in number—which could be referred to legs.

The abdominal segments invariably taper to some extent toward the tail; sometimes the tapering is scarcely visible on the anterior segments, and it is always more pronounced posteriorly, but here as before there are nearly all shades of difference between individuals, the extremes of which may again be represented in figs. 5 and 9; in the former of these the basal abdominal segments are only about half as broad again as long, and the middle ones are about square; while in the latter, the basal abdominal segment is more than twice as broad as long and it is only the terminal segment which is square. As a very general rule, the segments are quadrate, with very gently convex sides, and slightly and equally rounded anterior and posterior lateral angles; but in a few cases, as in fig. 9, the anterior angles are considerably more rounded than usual, and the posterior angles, besides being square, are furnished with a faint posterior extension, bristle, or tapering cluster of hairs (it is impossible to say which, but the last is the most probable). This same posterior set of appendages may be seen more or less distinctly in some of the other specimens, where the segments have the posterior angle as rounded as the anterior, but otherwise resemble this fig. 9 (as in fig. 4), or in which the segments are of the normal form, as in fig. 6, which represents the specimen which apparently furnished the figure which has hitherto been current, and in which these appendages appear more decidedly as hairs, being more spread out, and also as attached to the posterior thoracic segments.

The surface of the abdominal segments is in general flat, but not quite uniform, at least on many specimens. There appear to be two kinds of inequalities, one of which from its infrequency and position seems to be accidental, perhaps due to pressure. This is seen in fig. 16, in sharp lines close and parallel to the margin. The other, however, though often obscure, is too common to be so considered, and consists in a longitudinal series of slight ridges, laterally convex, and extending the whole length of the abdomen, dividing the segments into equal or subequal transverse thirds, of which the middle third is apt to be the largest. This may be seen in figs. 1, 6, 15. Besides these, there is nearly always some median mark of greater or less intensity, indicating probably the track of the alimentary canal. Two specimens which I have figured (figs. 2, 11) show this in a marked degree, the remains of a tube which extended the entire length of the body being visible. It is much more pronounced on the abdominal segments than elsewhere, but in fig. 2 more distinct on the anterior half of the abdomen, while in fig. 11 it is more distinct on the posterior half, where it is clearly at least double, being turned upon itself between the fifth and sixth abdominal segments, forming there a distinct rounded loop, and again more obscurely on the front of the eighth segment. To correspond with this, we have in fig. 2 a distinct horse-shoe shaped depression superposed a trifle laterally on the median groove at the posterior end of the fifth abdominal segment, and a shallower, smaller, circular depression in which the groove appears to terminate on the front of the seventh abdominal segment. From these it would appear reasonably clear that a slender alimentary canal, nowhere expanding into a well marked stomach, doubled sharply upon itself at or near the seventh abdominal segment, and after this doubling at the hinder extremity of the fifth abdominal segment, resumed its former course, the whole of the sixth segment and at least a part of the seventh having three parallel sections of the canal passing through the middle.

The variations in form of the different segments of the abdomen have been mentioned. It remains for us to speak of the curious variations of the terminal or ninth abdominal segment, and of its special appendages. The general relation of this segment to the preceding as well as its ordinary form is shown in figs. 1, 10 and 16, where it is quadrate but well rounded, tapering and about two-thirds as large as the preceding joint. In some cases, however, as in fig. 9, it is very small, and its separation from the preceding joint hardly noticeable, while at the other extreme, as in fig. 7, it is scarcely smaller than the preceding segment and longer, if anything, than broad. But the most interesting feature in this segment is the discovery in a few specimens, as in figs. 9 and 11 and to a slight degree in figs. 2 and 16, of appendages. There is an outer pair of slender styles, a little shorter than the penultimate segment, directed backward and a little divergent; and a much shorter pair, or perhaps only projections of the pygidium, lying between the longer styles.

As there is not a single specimen among the hundreds I have seen showing a lateral or even a partially lateral view, the insect could not have been cylindrical but must have been considerably flattened. The variation in the general form of the specimens, as preserved, indicates a not very corneous or rigid integument, since the shape of single segments varies considerably. Yet the general form is as a rule so uniform (as appears in fig. 8, where a number of specimens are exhibited just as they lie on the stone, much better than my selection of other specimens to be drawn for some particular feature) that we must consider the integument to have been at least coriaceous, and the varying proportions of single segments to depend, partly at least, upon the greater or less exposure of the intersegmental membrane.

When we come to consider the probable affinities of a larva having the structure above described, we are at a loss. No living form seems to be at all nearly allied to it. It would appear on general grounds to be either coleopterous or neuropterous, and from its aquatic habit to be more likely neuropterous than coleopterous; but further than this one must tread largely on conjectural ground. The structure of the head, in which the only recognizable appendages appear to be nearly or quite globular and chitinous, the absence or extreme brevity of the legs in connection with a plainly flattened body, and a terminal segment provided with cerci, are combinations and features very extraordinary. The only coleopterous larvae which seem at all to remind one of their general appearance are the Silphidae, all the larvae of which now known prey upon decaying animal and vegetable matter or live upon fungi, and none are aquatic: the Lampyridae, which are equally out of the question; and the Heteroceridae, which have no terminal appendages. These larvae, besides having a general form somewhat resembling that of Mormolucoides, have a flattened body,[1] short legs, and the Silphidae also a small head and distinct anal cerci, besides posterior lateral extensions of, or appendages to, the abdominal segments; but they have also comparatively small and tender mouth-parts; and the Silphidae stout, jointed antennae of considerable length, while their legs are usually, at least, as long as the greatest width of the body; and besides the ordinary nine segments of the abdomen, there is in the Silphidae the strongly protruding pipe-like pygidium, for which there is no homologue in Mormolucoides, unless the inner pair of cerci be taken as representing a completely forked pygidium. When we add to these differences the peculiar habitat of the living Silphidae, and the similar terrestrial haunts of

[1] In Heterocerus it is cylindrical.

the Lampyridae and Heteroceridae,[1] we shall be loth to assert a close affinity with these groups. Such groups of Coleoptera as have aquatic larvae show, however, no points of resemblance at all to Mormolucoides, and it seems, therefore, far more probable that they are neuropterous.

In support of this view, we have on general grounds, the flattened and posteriorly tapering form, much more common in Neuroptera than in Coleoptera, besides the terminal cerci, and posterior lateral appendages of the abdominal segments — features much more in accordance with the structure of those groups of Neuroptera to which they seem most nearly related, than with the structure of any Coleoptera.

These groups are the Perlidae, Ephemeridae and Sialidae, in all of which the larvae are at least in large part aquatic. In each of the first two of these groups, there is a remarkable uniformity of larval organization, and they seem to differ so much from Mormolucoides as to make it unwarrantable for us to look for intimate relationship with them. In Perlidae, for instance, we have a prothorax distinctly differentiated from the other thoracic segments, and the latter bearing at a comparatively early age, as in Blattariae, indications of the coming wings in the form of pad-like expansions of the outer angle of the said margin; we have also long and prominent antennae, very long and large flattened legs, anal cerci of great length, and no sign of an inner pair of cerci. In Ephemeridae, we have an entirely different form, equally discordant in its relations to Mormolucoides. The legs are nearly as long and stout as in Perlidae, lateral respiratory filaments cover the dorsum of the abdominal segments, the head bears stout, and often long antennae, while the terminal segment is almost invariably armed, not only with outer large, long, feathered anal cerci, but also with a similar, single, median style, even when the latter is absent from the imago; two inner styles are never present.

The comparative uniformity of larval structure among the diverse genera of each of these two groups prevents us from believing that Mormolucoides with its very different structure could by any possibility be included in either of them. Not a trace of thoracic wing pads or abdominal respiratory filaments can be seen on the hundreds of specimens examined. The great length and size of legs and multiarticulate antennae in both the groups, find no counterpart in Mormolucoides, and the appendages of the terminal segment are altogether different.

Not so, however, or not by any means to so great an extent, when we compare the larvae of Sialidae. Here we find a considerable greater range of characteristics, so that it is not so easy to recognize a common facies among them. But we may note one or two characteristics by which they approach much more closely our fossil type. All the appendages,—antennae, legs and (often) the cerci, are shorter and slenderer than in the two groups last mentioned. In some, the antennae at least are comparatively insignificant. The mandibles in some are very stout, and though long in all that are known may well be believed to be capable of modification in this regard. The abdominal segments are furnished with lateral filaments, projecting backward from the posterior outer angles. The appendages of the terminal segment vary very much, some having a single median style of considerable length, others a shorter lateral pair, in some cases furnished api-

[1] The Heteroceridae live near but not in water.

cally with recurved hooks. The objections to considering this as the most nearly allied group are the considerable size of the legs even when least developed, the great size of the head, which is at least as large as the segments behind, and the slight differentiation of the prothoracic segment shown at least in its larger size.

I had reached the conclusion that upon the whole we might look upon the Sialidae at the group of insects to which Mormolucoides was the most nearly allied (though still regarding the conclusion as provisional) when it received a curious support from an unexpected quarter — the internal structure of the larva. I have said that several specimens of Mormolucoides showed traces of the alimentary canal, and that in two of them (figs. 2, 11) in the posterior part of the body it doubled twice upon itself, covering with its triplication the sixth abdominal segment and parts of others, indicating a convolution of the small intestine. Looking at the published accounts and figures of the internal organs of the larvae of the three groups of Neuroptera we have been discussing, I find that the digestive tract, so far as known, is invariably straight and simple in both Perlidae and Ephemeridae, while a triplication of the small intestine is not unknown in Sialidae, being distinctly figured and described by Leidy in *Corydalis cornutus*,[1] where it covers the fifth abdominal segment, or the one next in advance of that in which we have found it in Mormolucoides. The only other figure of the digestive tract of a Sialid larva, which I have found, is that of *Sialis lutarius* published in the same year by Dufour,[2] where it is figured as perfectly straight and described similarly as "droit comme celui de l'insecte ailé." Several species in their perfect state, in groups closely allied to the Sialidae and sometimes placed with them, such as Panorpa, have a similar triplication of the small intestine, and it is also found in the larva of Myrmeleon as figured by Dufour.[3] These seem to be fair corroborations of the conclusion independently reached, that Mormolucoides is probably the larva of a Sialidan neuropteron. It has special interest from the fact that it is the oldest known insect larva.

EXPLANATION OF PLATE 45.

All the figures represent *Mormolucoides articulatus*, and all but fig. 3 were drawn by J. Henry Blake. Fig. 8 is natural size; fig. 3 enlarged about 5 diameters; the others enlarged 3 diameters.

Fig. 1. A specimen from Montague, Mass., collected by Prof. O. C. Marsh and in the Peabody Museum of Yale College. The head is smaller than usual.

Fig. 2. From the same place and collection as the last and on the same slab as fig. 16. Although imperfect, the head and first thoracic segment wanting, it shows remarkably a sharp median groove, which can be nothing else than the digestive tract, with the indication of its twice doubling on itself at the end of the fifth and base of the seventh segments. A slight indication of one of the anal styles is also seen on the last segment.

Fig. 3. The head and first thoracic segment of a specimen in the Yale College Museum as drawn many years ago by S. H. Scudder. It shows the apparent division of the head into two segments, then supposed to be head and first thoracic segments.

Fig. 4. Specimen from Montague, Mass., collected by Professor Marsh and now in the Peabody Museum at New Haven. It shows a head of unusual breadth, basal abdominal segments which are larger than the thoracic, and slight indications of the lateral appendages of the abdomen.

Fig. 5. Specimens from Turner's Falls, Mass., marked No. 1,405 in the Shepard collection of Amherst College. Figs. 11 and 12 are on the same slab. This specimen shows well the lateral marks of the thoracic segments interpreted as possibly legs, a well marked differentiation of the thoracic and abdominal segments, and an unusual [illegible] in the latter.

Fig. 6. This specimen appears to be the original type of *M*[illegible]. It is on the same slab with fig. 15, marked as coming from the Horse Race, Gill, and numbered [illegible] in the Amherst College collection. There is not [illegible]

[1] Mem. Amer. Acad., IV, 162–168, Pl. 1–2 (1848).

[2] Ann. Sc. Nat. [illegible], IX, [illegible], Pl. [illegible] (1848).

[3] Mem. Sav. Etrang. Acad. Sc., VII, Pl. 12, figs. 175, 177 (1841).

[illegible] ction which bears a very old printed label with the original name, and this specimen is the [illegible] appendages are distinct. It has, moreover, been tooled to some extent and bears no small [illegible] Hitchcock's plate. Apart from its interest it would have been drawn at this time if only to [illegible] ges of the abdomen, which seem here to be supplied also to the last thoracic segment.

[illegible] slab in the Amherst College Cabinet. Remarkable for the very small size of the thoracic seg- [illegible] narrower than the anterior, but no wider than the posterior abdominal segments. It is the [illegible] showing such a feature, and is the more marked because the thoracic segments are, if anything, [illegible] Figs. 9 and 13 are on the same stone.

[illegible] on Montague, Mass., numbered 1,637 in the Yale College Museum and collected by Prof. O. C. [illegible] to show the abundance of larvae on a single stone, although other instances could have been given [illegible] two or three times as numerous. This was selected simply on account of the small size of the slab. [illegible] marked a is represented enlarged in fig. 10.

[illegible] Specimen from the same slab as figs. 7 and 13. It is one of the most interesting seen, as it is remarkable [illegible] unusually symmetrical and perfect development of both the lateral and terminal appendages of the abdom- [illegible] which together show in no other specimen seen, but also for the symmetrical and unusual fusiform shape [illegible] last segment is unusually small. The head too shows some signs of the frontal lobes.

[illegible] The specimen marked a on fig. 8 enlarged, in which the main interest centres in the head, which is unusually [illegible] from a lateral displacement of the frontal lobes, as explained in the text.

[illegible] On the same slab as figs. 5 and 12. This is drawn to show the unusually clear doubling of the alimentary [illegible] between the fifth and sixth abdominal segment. On the front part of the eighth segment, the left hand [illegible] to pass beneath that on the right on the commencement of its recurrent course, but it does not show clearly [illegible]

[illegible] On same slab with figs. 5 and 11. Head of more than the usual size, showing an unusual basal expansion.

[illegible] On the same slab with figs. 7 and 9. It is especially interesting on account of the fine development of the [illegible] of the head.

[illegible] Specimen from the Horse Race, Gill, Mass., numbered [illegible] in the Amherst College Collection. The head is un- [illegible] rather small; the thoracic appendages (or sculpturing) unusually distinct and angular; the abdomen [illegible] great regularity, and the last segment is supplied with all the appendages. As drawn on the plate the last [illegible] perhaps a little too long.

[illegible] On the same slab with fig. 6. The special feature is the nearly uniform size of the body throughout and the [illegible] head, sunken nearly out of sight within the thoracic segment behind it.

[illegible] From the same slab as fig. 2. The specimen is of unusual size, the head has an unusual basal enlargement, [illegible] of one of the terminal styles is seen on the last segment.

XVI. Note on the supposed Myriapodan Genus Trichiulus.

By Samuel H. Scudder.

Read April 21, 1886.

Two years ago I published in the Memoirs of the Boston Society of Natural History the description of a genus of supposed hairy myriapods, Trichiulus, from the beds of Mazon Creek in Illinois, of which three species were distinguished. A short time ago [illegible] attention was again called to these specimens by Mr. R. D. Lacoe, whose collection is very rich in remains both of plants and animals from the carboniferous period, and in [illegible] all the types of the species described. Mr. Lacoe was convinced that at least two of them should be regarded as the terminal circinate portions of ferns. Dr. H. B. G[illegible] of Dresden (who had made a similar mistake in regarding a frond of Scolecop- [illegible] myriapod, to which he gave the name Palaeojulus) also wrote me somewhat [illegible] effect, and I have accordingly reëxamined the original specimens by the favor [illegible] in the light of half a dozen undoubted coiled fern-tips from his collection, [illegible] with the result that there is no doubt whatsoever that they are ferns [illegible] or one of its allies, preserved obscurely at the time of their par- [illegible] the name Trichiulus must disappear. The only specimen not re- [illegible] *T. nodulosus*, figured on pl. 27, fig. 1.

XVII. A Review of Mesozoic Cockroaches.

By Samuel H. Scudder.

Read January 20, 1886.

Six years ago, when I published a revision of all the paleozoic cockroaches then known, I was obliged to resort entirely to existing forms in the comparisons instituted between the wing structure of the ancient types and that of those of later times. Illustrations indeed and partial descriptions existed of more than thirty mesozoic forms, but since many of these were very imperfect, and many vaguely drawn, any attempt to reach definite conclusions concerning them, without specimens themselves from that period to examine, seemed futile.

It was my hope that, since structural distinctions of fundamental importance and of complete uniformity were shown to exist between paleozoic and recent cockroaches, rendering an examination of the mesozoic forms most desirable, some English naturalist would undertake the task; for it was evident, from the illustrations already given by Brodie and Westwood, that the British Lias and Oolite were especially prolific in these forms, and that abundant material must exist in public and private collections for the elucidation of the problems suggested.

This hope has not been fulfilled; but an unexpected discovery of Triassic cockroaches in considerable abundance in the South Park of Colorado rendered the examination of other mesozoic forms still more desirable, and I determined, therefore, to study the question myself as best I could. My venerable friend, the Reverend P. B. Brodie, the pioneer student of British fossil insects, kindly came to my aid by sending me, from his unexampled collection of British mesozoic insects, such specimens as seemed to be cockroach wings. In this way, I have not only been able to study from the specimens themselves as many as ten of the wings which had before been described and figured, but nearly three times as many forms now published for the first time. The study of these naturally threw much light upon obscure points in the illustrations of species not studied from the specimens, both in England and on the continent,—a number less than those seen, and most of them easily interpreted with their aid and often without it. The fruits of that study are herewith presented, with my best thanks to the Rev. Mr. Brodie for his generosity. The number of mesozoic types now slightly exceeds the paleozoic, though their relative proportion to the rest of the synchronous insect fauna is far less than in the earlier period.

As in the paleozoic cockroaches, so here, most of the remains consist exclusively of front wings, and the principal guide to our knowledge of these early forms comes necessarily from a study of the neuration of these parts. This study, in the case of the paleozoic cockroaches, led to the discovery of some features of fundamental importance, by which the front wings of paleozoic cockroaches could be invariably distinguished from those of existing types. In paleozoic forms all of the main veins are completely independent, and the anal nervules fall at regular intervals upon the inner margin. In existing types, two or more of the main veins are amalgamated, either completely or to a large extent, while the nervules of the anal area strike the anal furrow, or at least compose a fusiform bunch directed toward the tip of the furrow. In consequence of these distinctions the paleozoic forms were distinguished as a separate group under the name Palaeoblattariae.

This discovery naturally led to the enquiry: Which of the veins in the modern tegmina have undergone the blending process? An examination of existing species showed that, as a rule, the veins were still independent in the hind wings, and an opportunity was therefore afforded of investigating the subject by the comparison of the front and hind wings of many modern types, and the conclusion reached that in modern tegmina the scapular and externomedian veins were those which had blended.[1]

This conclusion was shortly shown to be incorrect for mesozoic types, by the discovery, above mentioned, of cockroaches in the Triassic beds of Colorado, where a series of forms were found associated, some of them belonging to the Palaeoblattariae, and some with blended veins, allowing a more exact comparison than had before been possible. The conclusion newly reached from their study was that "when we compare the series of genera near the boundary line of the departure of the Palaeoblattariae toward later forms (those paleozoic cockroaches allied to Petrablattina) and especially those [Palaeoblattariae] brought to light by the discoveries at Fairplay, we find that in the mesozoic species at least, it is the mediastinal and not the externomedian vein which has blended with the scapular, although the externomedian also may become blended with the others in living types. This amalgamation has proceeded by the enlargement of the scapular area, which has crowded the mediastinal toward the base of the wing, whose few remaining branches finally become attached to the scapular vein, no trace of their former dependence remaining visible."[2]

The present study shows that this conclusion must also be modified by a somewhat further extension. The above statement is true of about two-thirds of the species, but there are also others, both in the Lias and the Oolite, in which a different or even a greater variation is found, the externomedian vein being sometimes united, throughout at least part of its length, with the scapular, or it may be wholly united with the intermedian, and in both cases, the mediastinal may or may not also be united with the [illegible]. The variation is therefore already very great in Liassic times, although it [illegible] its maximum only in the later Oolite. With the exception then of about a [illegible] species of Palaeoblattariae in the Triassic rocks, all of the mesozoic cockroaches, [illegible] have front wings in which two or more of the veins are coalesced.

As [illegible] the other distinction, drawn from the anal area, there is much diversity,

[1] [illegible]

[2] Amer. Journ. Sc. (3) xxviii, 201.

and in fact very imperfect knowledge, this region being frequently missing in the fossils. In most of the genera the anal nervules, so far as known, strike the margin, but in some the species vary in this respect; in others their course is entirely unknown, while in such as are perfectly preserved in the most prolific genus, Mesoblattina Geinitz, they impinge indeed upon the margin, but show a decided tendency to direct themselves toward the tip of the anal furrow, as in many modern forms. This feature cannot therefore be said to have become fairly established in mesozoic times.

These changes in the general structure of the front wing are no doubt but one expression of the increasing heterogeneity in the neuration of the front and hind wing which was almost entirely unknown in paleozoic times, but which has reached a high development at the present day. The remains of the hind wings of mesozoic cockroaches are indeed not sufficiently abundant to prove this, but we have grouped here under one generic name, Aporoblattina, such single detached wings as seem to be properly considered as such, and here the veins are entirely distinct. Another indication of this specialization on the part of the front wing is their increasing density, by which the neuration is in part obscured. This is not very marked, but in some species is unmistakable.

A further peculiarity of mesozoic species, as a general rule, is their small size. In a previous paper, before the number of paleozoic forms known was as great as now, the average length of their front wings was estimated as 26 mm., and there is no reason to suppose that that measurement would be altered by later discoveries to any extent worth mentioning. On the other hand, even the Triassic Palaeoblattariae already show a tendency toward that diminution in size which is well marked in the mesozoic Blattariae, for the average length of the former is only 16 mm., while in the mesozoic Blattariae as a whole it is still further reduced to 12.5 mm. Even this would be somewhat diminished (to 11.5 mm.) if we should omit the species from the middle Oolitic beds of Solenhofen, all of which were large and some gigantic, one reaching a length of 60 mm. That this should be the case seems a little unexpected when we find the species of the upper Oolite (of England) a little smaller as a general rule than the Liassic forms. This somewhat curious fact led me to ask what should be considered the average size of the modern cockroach. I accordingly took Brunner's Système des Blattaires and tabulated the measurements of the front wings given there whenever the material was at hand for the purpose, to the number of 213 species. One measurement only was taken for each species and where the sexes differed (as often excessively) these also were averaged. Of course the apterous species had to be omitted, and it was plain that the result would be too large as the larger species find their way to collections much more rapidly than the smaller forms. The general result was that the average size of the front wings of recent cockroaches is 18.2 mm. which is considerably more than that of the mesozoic species, and much less than that of the paleozoic forms.

As regards the relative geological position of these mesozoic cockroaches two facts are patent: 1°. No species has been found in more than one deposit. 2°. While all three of the genera of the Trias are peculiar to it (some of the genera of the Triassic Palaeoblattariae have also been found in lower paleozoic rocks) and two genera are found only in the upper Oolite, all of the genera found in the intermediate Lias also occur in the

Oolites. The genera peculiar to the upper Oolite are however very poor in species, one having only one and the other only two representatives, while the genera common to the Lias and Oolite are generally prolific in this respect.

Of the seventy-seven species of Blattariae mentioned in the following pages, not including those found in the Appendix, three are found in the Trias, seventeen in the Lias, five in the middle Oolite and forty-six in the upper Oolite, besides three whose precise horizon is unknown.

A comparison of the venation of the tegmina of mesozoic and recent cockroaches, to determine, as far as possible, the immediate relations of the former to existing forms, gives little satisfaction. Still, Mesoblattina and Rithma may be said to bear considerable resemblance to the Phyllodromidae—as Phyllodromia, Apolyta and Thyrsocera, for example—and the peculiar neuration of Elisama is in part repeated in the Panchloridae (*e. g.*, Panchlora, Leucophaea, Nauphoeta) and also occurs in some Phyllodromidae (Thyrsocera) and Epilampridae (Paratropa, Epilampra). Scutinoblattina also reminds one in certain features of some Epilampridae, like Phoraspis. The other genera, and particularly Blattidium and Pterinoblattina, appear to have no relations to any special type. As a whole, then, it would appear as if the *Blattariae spinosae* approached closer to the mesozoic forms than the *Blattariae muticae*.

As I have already stated, the most fundamental distinction separating the mesozoic from the paleozoic cockroaches is in the change which the principal nervures of the upper wings have undergone, by the basal or total amalgamation of some of them,—a change which reaches its culmination in living cockroaches.

On the basis of these differences, mesozoic cockroaches may be divided into three groups: *a*, those in which only the mediastinal and scapular veins are amalgamated; *b*, those in which the externomedian is united with one of the veins on either side of it; and *c*, those in which either the mediastinal, scapular and externomedian veins are all united; or there are two lines of union, one between the mediastinal and scapular, and the other between the externomedian and internomedian veins, *i.e.*, where, besides the union of the mediastinal and scapular veins, the externomedian also allies itself in whole or in part with the united mediastino-scapular, or with the internomedian. In all mesozoic cockroaches, excepting the Triassic Palaeoblattariae, amalgamation of some of the veins occurs; for a further study of Pterinoblattina convinces me that my first interpretation of its neuration was incorrect, in that what I had taken for the internomedian vein is really the anal, and that what was looked upon as the externomedian must be regarded as the united externomedian and internomedian veins.

a. The mediastinal and scapular veins of the upper wings, and these only, are amalgamated.

CTENOBLATTINA gen. nov. (κτενωτός).

In the tegmina of this group, which are minute, the humeral angle, usually consider[illegible] cockroaches, is obliquely docked, and the united mediastinal and scap[illegible] broad area, at first nearly one-half of the breadth of the wing, and [illegible] the tip, provided with numerous parallel more or less forking branches.

The internomedian occupies a very similar belt on the inner side, extending nearly or quite to the tip; and between them the pinched externomedian, enlarging a little toward the tip, finds narrow quarters. The anal area is very brief, but the character of its venation is not known.

Two of the species come from the English Purbecks; the third from the German Lias.

Ctenoblattina arcta sp. nov.

Pl. 16, figs. 1, 2.

This minute species, as may be seen by fig. 2, has its venation somewhat obscured, partially perhaps by the thickness of the integument. In its interpretation, in fig. 1, it is probable that the internomedian area is given too little width, as its apical nervules are given too little curvature. The form of fig. 2 is more correct. The wing is broadest at the extremity of the anal area, just before the end of the basal third; up to this point it increases rapidly in size, the humeral angle being strongly docked, and beyond tapers very gently to a well rounded tip. The costal area (as the united mediastinal and scapular areas may be termed) is crowded with nervules, every alternate one appearing a little heavier than the others, so that the intermediate are probably intercalary veins, as one would judge also from their absence from the internomedian area, where the veins are more distant. Excepting for the simple division in the middle of the basal half of the wing, the externomedian vein does not fork before the middle of the wing, and then but narrowly, but the whole of this region is obscure, though it seems certain that it occupies outwardly nearly the whole tip of the wing. The anal furrow is distinct and very strongly arcuate. The anal area is neither elevated nor depressed, the whole wing being entirely flat. The wing is about 2.7 times longer than broad, its length being 5.5 mm. and its greatest breadth a little more than 2 mm.

The specimen comes from the English Purbecks (precise locality not known), and occurs on a stone of a very pale sordid brown color, on which the veins appear dark brown; it was received from Rev. P. B. Brodie.

On account of the obscurity of the venation, and its apparent derivation from the thickness of the integument, I formerly, from partial study, considered this a species of Heer's genus Legnophora, from the Trias, and so referred it, without name, in Zittel's Handbuch der Paläontologie (II, 766); but a severer examination has enabled me to trace the neuration, which cannot be made to accord with that of Legnophora.

Ctenoblattina Langfeldti.

Blattina Langfeldti E. Gien., Zeitschr. deutsch. geol. Gesellsch., 1880, 521, Pl. 22, fig. 3; *ibid.*, 1884, 571.

This species seems certainly to fall here, but Geinitz appears to have confounded the costal and inner margins. The externomedian vein resembles the foregoing more than the following species, but first forks much farther from the base. The wing is 5.5 mm. long and about 2.2 mm. broad. It comes from the Lias of Dobbertin, Germany.

Ctenoblattina? pinna.

[illegible] Wo[illegible] name.] Brodie, Foss. Ins. Eng., 118, Pl. 5, fig. 5.

B[illegible] Gieb., Ins. Vorw., 322.

B[illegible] *pinna* Heer, Viertelj. naturf. Gesellsch. Zürich, 1864, 290.

This species appears to belong here, but I have not seen the specimen and the obscurity of the drawing renders its location uncertain. It is badly broken at base, so that the humeral angle and anal area are (probably) entirely obliterated. The fragment is represented as nearly 4.5 mm. long, and its real length was probably about 5 mm. It differs from the preceding species in the uniform width and greater extension of the costal area, which must reach the very tip of the wing, the apparent absence of spurious nervules in the same area, the even slenderer externomedian area hardly expanding apically, and the very great width of the internomedian area, which occupies fully half of the wing.

It comes from the English Purbecks.

NEORTHROBLATTINA Scudder.

Neorthroblattina Scudder, Proc. Acad. Nat. Sc. Philad., 1885, 108.

In this genus the wings are about two and a half times longer than broad, with fairly well rounded apices, the costal area extending nearly to the tip, and in the middle of the wing occupying nearly one-half its width. The internomedian vein is of varying importance, and in the large anal area the veinlets terminate on the margin; the anal furrow is strongly arcuate, and deeply impressed.

All the species come from the American Trias.

The four species are *N. albolineata*, *N. Lakesi*, *N. rotundata* and *N. attenuata*, all found at Fairplay, Colorado. They were briefly described in the Philadelphia Academy's Proceedings, and will be fully discussed and figured in a paper devoted to this Triassic locality, so that it is only necessary here to indicate their apparent position in the series.

RITHMA Giebel (emend.).

Rithma Giebel, Ins. Vorw., 318; Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 113.

The wings of this group, as it is limited by me in the place above referred to, are generally rounded wedge-shaped, *i.e.*, slender and tapering (though the latter peculiarity is [illegible]ating in some even of the slenderest species) with the costal area large, occupying [illegible] or quite half of the wing, the main vein sinuous, generally conspicuously sinu[illegible] almost straight, terminating close to, sometimes even below, the tip. The [illegible] generally pretty large, vaulted, and filled with arcuate parallel veins which [illegible] the margin. The externomedian and internomedian veins are also sinuous [illegible] remaining space about equally between them, each forking considerably [illegible]ically. Their nervules, and especially those of the internomedian vein, [illegible] longitudinal than oblique. The genus stands midway between Neor[illegible] Mesoblattina, the flatness of the humeral field, and the great extent of the costal area distinguishing it from the former, the greater obliquity of the inferior nervules and particularly those of the internomedian area, as well as the parallel and similar course of the anal nervules, separating it from the latter.

Most of the species come from the English Purbecks, but two occur in the Lias of England and Switzerland.

Rithma Stricklandi.

Pl. 16, figs. 4, 5.

Blatta Stricklandi Brodie, Foss. Ins. Engl., 32, 118, Pl. 4, fig. 11 (2 figs.); Gieb., Ins. Vorw., 317.

Blattidium Stricklandi Heer, Viertelj. naturf. Gesellsch. Zurich, IX, 290.

By the favor of Mr. Brodie, I have had the opportunity of studying and redrawing the original of this species, which shows a complicated cross-neuration by the overlapping of the four wings and the tenuity of the membrane. This has enabled me to trace out the separate neuration of the tegmina, as shown in fig. 4, which would not have been possible from the original drawing, which was in other respects not wholly correct. No description accompanied the figure.

The most perfect wing is the upper wing of the left side, and this is only preserved sufficiently to show that it probably belongs in this genus and cannot be identified with any other of the species here referred to Rithma. The humeral area is very narrow, and is not differentiated from the rest by its flatness; the costal area of nearly equal breadth until close to the tip as in the next species, but the main vein has a slight sinuosity and no terminal inferior forked vein, and its branches are comparatively few and distant. So too, are the branches of the externomedian, which in other respects do not differ from the next species. In the hind wing, the costal area is much narrower and distinctly tapers apically. The inner bases of all the wings are wholly obscured by the meso- and metathoracic scuta, which come to the surface as large spots, so that there is no indication even of the anal furrow; they indicate, however, the position of the bases of the wings, enabling us better to judge of their exact length, while the curves show where the tip must lie. Judging by these, the length of the wings was 12 mm.; the breadth of the two wings at rest 5.5 mm.; that of one of them, probably about 4 mm.; and the width of the mesothorax, 3 mm.

The specimen comes from the Purbecks of the Vale of Wardour, Wiltshire, England, and is of the same color as the dirty brown stone on which it rests, excepting that parts of the thorax are black, the veins varying from light to blackish brown. The surface of the specimen is very slightly convex, and the veins are slightly impressed.

Rithma Gossii sp. nov.

Pl. 16, fig. 15.

This species is founded on a nearly perfect wing in which only the anal area is missing. The wing is of nearly uniform width, nearly three times as long as broad, with a well rounded tip. It is of the same color, veins and all, as the dirty, chalky-white matrix;

the wing shows the upper surface and is arched transversely, the costal area roof-like, the veins running in slight furrows. It is peculiar for having, like *R. Stricklandi*, a very straight and uniform costal area, but the depressed humeral field is of the usual width, though rather short, the costal veins are numerous and crowded, and a supplementary anterior, forked, apical vein carries the area quite to the tip of the wing; the latter characteristic may well be individual. The externomedian and internomedian veins divide their space between them very equally with abundant, forked, almost perfectly straight veins, the internomedian area terminating just before the apical curve of the wing, and the externomedian first forking far before the middle of the wing. The anal furrow is no more depressed than the other veins, strongly arcuate in its basal half, straight beyond, with a slight outward curvature at the tip, which is opposite the first forking of the externomedian vein. The course of the main externomedian vein is almost exactly down the middle of the wing, and the nervules on either side of the wing are about equally crowded.

Length of wing, 6.5 mm.; breadth, 2.2 mm. The species is named for Mr. Herbert Goss, who has done so much in recent years to foster in England an interest in fossil insects. It comes from the English Purbecks and was submitted to me for study by the Rev. P. B. Brodie.

Rithma disjuncta sp. nov.

Pl. 46, fig. 11.

A single wing in which the characteristics of the neuration are well shown, although only fragments of the border appear. It is possible nevertheless to judge with probable accuracy of the form of the wing, which seems to have been pretty regularly obovate and a little more than two and one-half times longer than broad. The wing is perfectly flat on the dirty brown stone, with black veins and more or less broken black intercalary veins, especially in the costal area. The humeral field must have been very slight; the mediastino-scapular vein pretty strongly sinuous in the basal half, nearly straight apically, the costal area occupying in the middle nearly half the wing, terminating just above the apex, and being filled, including the intercalaries, with numerous, crowded, oblique, simple veins. The externomedian vein follows the same sinuous course, is forked not far before the middle of the wing, the lower branch again forked at less than half-way to the margin; probably all fork again beyond, but the specimen is broken here. The internomedian reaches just about as far out as in *R. Gossii*, is doubly arcuate, and has three or four inferior, straight, parallel, oblique branches. The nervules of the inner are not nearly so crowded as those of the costal margin. The anal furrow is not depressed, slightly arcuate at base, straight and oblique beyond, reaching the margin opposite the first forking of the externomedian vein.

Probable length of wing, 5.3 mm.; breadth, 2 mm. The species is the smallest of the genus. It comes from the Wiltshire Purbecks, and is in the collection of the Rev. P. B. Brodie.

Rithma liasina.

Pl. 16, fig. 7.

[Without name] Brodie, Foss. Ins. Engl., 101, Pl. 8, fig. 12.
Blattina liasina Gieb., Ins. Vorw., 317.
Blattidium liasinum Heer, Viertelj. naturf. Gesellsch. Zürich, IX, 289.
Rithma liasina Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 114.

By the kindness of Rev. Mr. Brodie, I have had the opportunity of studying the original specimen shown in Pl. 8, fig. 12, of his work, and find that it differs so much from the figure given that a new drawing is necessary, which shows better than the original that it belongs in Rithma. The wing exhibits an under surface on a dirty light brown stone, on which the veins show slightly darker; it is very slightly concave, the interspaces being slightly depressed in general, and rather markedly depressed where figured in white. The wing is largest just before the middle, tapers regularly beyond, and probably had a well rounded tapering tip, but the apex is much broken. The costal margin is gently arcuate and the inner margin straight. The humeral field is very large, broad and extends to the middle of the wing, is flat, and does not partake of the concavity of the rest. The mediastino-scapular vein is rather strongly sinuous and terminates just above the tip of the wing, the broadest part of the costal area being in the middle where it occupies nearly half the wing. The veins of this area are tolerably numerous, longitudinally oblique, parallel, the basal ones simple, the apical forked. The externomedian vein and its branches are disposed almost exactly as in *R. disjuncta*, but occupy a little less space on the margin, being more displaced by the internomedian veins, which from base apically change their course conspicuously, the basal branches being almost transversely oblique with a slight terminal curve outward, the outer arcuate at root and nearly longitudinal beyond; the branches on the costal and inner margins have a similar distance apart. The anal area is very large, the furrow being roundly bent in the middle and transversely oblique beyond, but yet reaching nearly or quite half-way down the inner margin and opposite the basal forking of the externomedian vein; it is not prominent, and would appear to have been no more strongly depressed (on upper surface) than the other veins.

Length of fragment, 12 mm.; probable length of wing, 14.5 mm.; breadth of same, 5.25 mm. The specimen comes from the Lias of Wainlode, Strensham, England.

Rithma formosa.

Blattina formosa Heer, Lias-Ins. Aarg., 15, Pl., figs. 41, 42; Id., Urw. Schweiz, 83, Pl. 7, figs. 1, 1*b*.
Rithma formosa Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 114.

In this species, in which the typical rounded wedge-shaped form of the wing is excellently shown, and only interfered with by the lateral expansion of the anal area, perhaps due to displacement by the crushing of its vaulted form, the humeral field is very narrow and small, the costal area broad, equal and appearing to embrace the tip (the figures are not quite clear nor consistent), while in no other species is the fan-like disposition of the rays of the externo- and internomedian veins so well shown as here; they divide the field very equally between them, the externomedian vein forking far back toward the base; and the large anal area with its almost regularly arcuate anal furrow and parallel veins occupies about a third of the inner margin. The nervules on the two sides of the wing are of similar distance apart and rather crowded. I have not seen specimens of this species but describe it briefly from the figures.

The length of the wing is 15.5 mm; its breadth 5.5 mm; it comes from the Lias of Schambelen in Switzerland, and is known from a single wing.

Rithma Morrisi.

[Without name] Westw., Quart. Journ. Geol. Soc. Lond., x, 390, Pl. 18, fig. 34.
Rithma Morrisi Gieb., Ins. Vorw. 319; Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 113, 114.
Blattidium Morrisi Heer, Viertelj. naturf. Gesellsch. Zürich, IX, 290.

A single nearly perfect wing, known to me only by Westwood's figure, is closely related to *R. formosa*, but is smaller, has its greatest width close to the base, has even more crowded veins, with more abundant dichotomizing and a much smaller not protruding anal area. The humeral field is very small but not slender, the costal area as in *R. formosa*, but terminating just above and not embracing the tip, the median veins much as there but with more abundant forking of the branches. The anal furrow appears to be bent roundly in the middle and to be oblique apically, yet not to reach even a fourth way down the inner margin.

The length of the wing is 10 mm. and its breadth nearly 4 mm. The specimen comes from the Lower Purbecks of Durdlestone Bay, England.

Rithma purbeccensis.

[Without name] Westw., Quart. Journ. Geol. Soc. Lond., x, 390, Pl. 18, fig. 32.
Rithma purbeccensis Gieb., Ins. Vorw., 319; Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 113, 114.
Blattidium purbeccensis Heer, Viertelj. naturf. Gesellsch. Zürich, IX, 290.

This wing is only known to me as the last, and it is less perfect, but has characteristics which easily distinguish it. It is probably broadest in the middle of the basal half and has the typical wedge shape. The humeral field is large and broad, tapering much apically and reaching more than one-third way down the costal margin. The mediastino-scapular vein is very sinuous, making the costal area broadest in the middle of the apical half of the wing where it occupies two-thirds of the entire breadth, but as the costa curves upward again apically and probably strikes the exact tip of the wing, it narrows rapidly at the end; the area is filled with crowded, sinuous or arcuate, partially forked nervules, which are much more crowded than the distant, slightly forked, sinuous branches of the externomedian and internomedian veins, which appear to divide the space to the anal furrow about equally between them. The anal furrow is strongly arcuate in the middle and terminates as far out as the humeral field and far beyond the basal branching of the externomedian vein; anal veins not preserved.

The length of the fragment is 10.5 mm. and the presumed length of the wing 11.3 mm.; its breadth is 3.5 mm. It comes from the Lower Purbecks of Durdlestone Bay, England.

Rithma Daltoni sp. nov.

Pl. 46, fig. 16.

The single wing sent to me by Mr. Brodie is preserved in a similar manner as *R. purbeccensis* and was at first taken to be the type of that species, but a closer examination showed that if the latter has been correctly drawn by Westwood, this must be distinct from it. The wing is of the same color as the dirty chalky white stone on which it rests, the veins even showing no color distinction. These are finely impressed, showing as well as the slightly arched surface that its upper side is seen; there are some faint intercalary veins in the costal area not shown in the figure; the anal furrow is no more deeply incised than are the others, and the humeral field is flat and at a lower level than the rest. The wing is undoubtedly broadest in the middle of the basal half, is wedge-shaped, tapering very regularly and considerably, with a straight inner and gently convex costal margin, to a somewhat pointed (here broken) tip. The humeral field, at first equal, tapers in the apical half, which reaches nearly to the middle of the wing. The mediastino-scapular vein is broadly sinuous, giving the costal area the same shape that it has in *R. purbeccensis*, including the entire tip of the wing, the extremity of the vein passing a short distance below the very apex; its branches are nearly straight, parallel and oblique, the early ones simple, the later, arising in the broadening field, forked, the forks originating on a line with the bases of the simple veins. The remainder of the wing is as in *R. purbeccensis*, only the branches are equally distant on the two sides of the wing.

Length of the fragment 10.75 mm.; probable length of wing 12 mm.; its breadth probably 4 mm., though the extreme breadth at the tip of the anal furrow is slightly less, or 3.85 mm. The specimen comes from the English Purbecks, and the species is named for Mr. W. H. Dalton of the Geological Survey of Great Britain.

Rithma Westwoodi.

Pl. 46, fig. 11.

[Without name] Westw., Quart. Journ. Geol. Soc. Lond., x, 390, 396, Pl. 18, fig. 22.
Rithma Westwoodi Gieb., Ins. Vorw., 318–319.
Blattidium Westwoodi Heer, Viertelj. naturf. Gesellsch. Zürich, IX, 290.

Among the specimens sent me by Rev. P. B. Brodie, one occurs which seems to be the type of Westwood's figure, since in all that I have seen the figure is reversed, and in this instance the resemblance is close. I am able, therefore, to describe this species from the original and find the doubts I expressed concerning its position (Proc. Acad. Nat. Sc. Philad., 1885, 113) hardly to be confirmed, though of all the species of Rithma it is the most closely related to Mesoblattina.

The under surface is exposed, the specimen being transversely concave, with elevated veins and concave interspaces; all are of the same color as the dirty chalky-white stone.

The wing is exceedingly slender and subcuneiform, being nearly four times longer than broad, its greatest breadth just before the middle, both costal and inner margins gently arcuate, and the tip somewhat produced. The outer half of the inner margin appears to be slightly broken, but is apparently narrowed to the very slightest degree. The humeral field is large, flat, rather regularly cuneiform, reaching about two-fifths way down the costal margin, separated by a ridge (furrow, if it were viewed from above) from the adjacent parts. The mediastino-scapular vein is strongly sinuous and terminates far below the tip of the wing, so that the costal area, which in the entire apical half of the wing occupies more and generally much more than half the breadth, embraces the entire tip and is filled with regular, straight or gently arcuate, simple or forked, parallel, not crowded branches. The externomedian and internomedian areas divide equally between them what little space is left between this broad costal area and the anal furrow. The anal area is large, the furrow, which is no more prominent than the other veins, being bent roundly and sharply in the middle, and yet reaching almost as far as the humeral field, and as far as the basal fork of the externomedian vein. No anal veins are preserved. The externomedian branches are only three or four in number, sinuous and longitudinal; those of the internomedian quite as few, nearly straight and oblique.

The length of the wing is 10 mm.; its breadth, 2.6 mm. It comes from the English Purbecks, and according to Westwood, from the lower members at Durdlestone Bay.

It is possible that the obscure specimen figured in Pl. 46, fig. 6, also belongs to this species. It is too imperfect to determine. The slenderness of the wing and the resemblance of the humeral field and anal furrow are very similar, but the form is less tapering, and the nervules, especially toward the tip, are much more crowded and more directly longitudinal. It is possible, however, that it should be represented as broader, as the inner edge comes against a slight elevation in the dirty chalky-white stone. Perhaps a closely allied species is indicated. It comes from the English Purbecks and was submitted to me with the other by Mr. Brodie.

Another species, apparently belonging to this genus, is indicated by the obscure specimen figured in Pl. 46, fig. 8. It differs from any in the decided tapering of the apical half to an almost pointed tip, but the neuration is too imperfect to indicate any further characters. Probably the right hand margin is the costal. The wing is flecked with reddish-brown, contrasting with the light brown color of the stone, the veins dusky. Its length is 7.25 mm., and its breadth, 2.6 mm.; and like the last it comes from the English Purbecks and was communicated by Rev. Mr. Brodie.

Rithma? minima sp. nov.

Pl. 18, figs. 2, 8*a*, 8*g*, 11.

[illegible] figured with others by Westwood, Quart. Journ. Geol. Soc. Lond., x, 383, 384, Pl. 15, fig. 11, the uppermost and the left hand of the two lowest objects.

[illegible] objects which probably belong together, as their relative sizes agree perfectly, the same light brown stone, and are referred here from slight indications only in the character of the wing. The species is certainly distinct from any known on account of its size alone, and the direction of the mediastino-scapular vein is such as to lead one to presume it terminated at the very tip of the wing, which is of an oval shape and rather broad for its length, tapering in the apical half to a rounded tip equally sloping on both sides. The anal furrow is not very strongly arcuate, but unusually transverse and the anal veins impinge on the margin. An upper surface is shown which is slightly domed. Length, 4 mm.; breadth, 1.9 mm.

The other object is a pronotum of a cockroach, 3.25 mm. broad and 2.3 mm. long, broadly and transversely oval, the hinder margin less rounded than the front margin, the disc slightly convex, with slight irregularities like gentle longitudinal plications, as seen in the figure (fig. 2), the delicate edge very slightly marked by a darker line. As it corresponds exactly to what we should expect of a pronotum belonging with the wing on the same stone, and is only about 2 cm. removed from it, and as no other known mesozoic species approaches it closely in size, there can be little doubt that they belong together. The specimens come from the middle Purbecks of Dorset, England.

The other objects found on this same stone are also figured on the same plate. One of them, *Pterinoblattina pluma*, is described elsewhere in this paper. Fig. 4 (8*b*) is fig. 14‡ of Westwood and considered by him as the wing of a grasshopper. Fig. 10 (8*f*) is fig. 14÷ of Westwood and considered by him as one of the Trichoptera. Fig. 12 (8*d*) is fig. 14* of Westwood, also considered by him as trichopterous. Fig. 13 (8*e*) is fig. 14⁑ of Westwood and named by him *Cercopidium Telesphorus*. These will be discussed at some future time, and are only mentioned here to explain the plate, according to Westwood's views.

MESOBLATTINA E.Geinitz.

Mesoblattina E. Gein., Zeitschr. deutsch. geol. Gesellsch., 1880, 519–520; Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 114.

This genus, proposed at first by Geinitz as a sub-genus for a couple of species of mesozoic cockroaches, on account of the course of the anal nervures, was afterwards extended by him to include another species, which disagreed in this particular from the others. In this he was right, inasmuch as the group, which should be accorded generic value, contains forms which vary considerably in this respect. The characters referred to in my paper on mesozoic cockroaches (see above) relating to the course of the internomedian and externomedian nervules seem to be more important. The genus was the most prolific of any in mesozoic times. The wings are generally slender and parallel sided or nearly so, though in not a few they taper as conspicuously as in most of the species of Rithma, and one species at least is broadly oval. The flat humeral field is nearly always large and conspicuous, and the costal area large as in Rithma, from which it is distinguished mainly by its greatest peculiarity, which is the basal sinuosity and subsequent almost completely longitudinal course of the externomedian and internomedian veins and all their branches, the latter even rarely touching the border before the apical half, and generally not before the apical fourth or fifth of the wing, while the anal furrow does not extend out after them, but meets the border at a broad angle. In addition to this, the veins of the anal area show in a considerable number of species (in many this part is not preserved) a strong tendency to run in a similarly longitudinal course, so that they trend from different parts of the area toward the outer lower extremity of the area, where they are closely clustered. This is an approach toward the generally longitudinal course of the anal veins in recent cockroaches, where they abut upon the anal furrow and not on the margin. The genus stands midway between Rithma and Elisama, the latter being a genus in which the peculiar course of the median veins is more conspicuous than here, but which has no such large anal area as is common to the species of this genus. Mesoblattina is far more abundant in species than any other mesozoic genus, being found in considerable abundance both in the Lias and in the Oölite, but especially in the latter. The species may be separated into two groups.

1. *The anal veins are parallel and end on the margin at equal distances apart.*

Mesoblattina Blakei sp. nov.

Pl. 46, fig. 12.

A single wing from which a considerable portion of the tip is lost, but which shows all the characteristic parts of the neuration almost completely. As restored on the plate, the wing is exceedingly slender, nearly four times as long as broad, with very parallel sides, the costal border gently arcuate, flattened in the middle and the inner margin nearly straight. The humeral field is very long, lancet-shaped, extending nearly to the middle of the wing. The mediastino-scapular vein is exceedingly sinuous, the area being broadest opposite the tip of the humeral field, where it is nearly half of the breadth of the wing, and extending (probably) only a little distance beyond the middle of the outer half of the wing; the nervules are oblique, simple, parallel, tolerably abundant. The externomedian vein first forks somewhat before the middle of the wing and has long, so far as can be seen simple, wholly longitudinal, or upward curving branches which trend so as probably to terminate on the tapering apex of the wing wholly above the middle line; probably they fork near the tip. The internomedian vein is divided back of the first forking of the externomedian into two branches, the upper of which forks near the middle of the wing and resembles one of the externomedian offshoots; the other has three or four inferior, sinuous, very longitudinal branches, all impinging on the outer half of the lower margin and rather more closely crowded than the costal nervules. The anal area is very large, extending very nearly as far out as the humeral field; the anal furrow is depressed, very uniformly arcuate, and the anal veins are very peculiar, appearing to consist of a mid-vein parallel to the anal furrow, dividing the area into two nearly [illegible] halves and furnished with longitudinally oblique parallel nervules which appear to [illegible] at equidistant points on the margin; and second, of a single slight vein midway [illegible] the first and the anal furrow, the termination of which is uncertain since the [illegible] half of the anal area is broken away, revealing beneath the very closely ap- [illegible] parallel, oblique offshoots of (probably) the anal area of the hind wing.

L[illegible] fragment 15 mm.; probable length of wing 19 mm.; width 5 mm. In the [illegible] anal area this wing is totally different from any other species. It comes [illegible] Lias of Alderton, Gloucestershire, England, and was sent me by Rev.

P. B. Brodie. It rests on a dirty brown stone, the veins being blackish. I have named it for Rev. J. F. Blake who has made some researches upon the Lias insects.

Next to this I place, doubtfully, a couple of forms which are evidently nearly related, and apparently belong in this vicinity, but are too imperfect to discuss fully until better material shall offer.

One of them (Pl. 46, fig. 3) has a large and long costal area in which the main vein is regularly arcuate and its oblique branches are distant at base and apically forked; an externomedian vein of little importance with two or three wholly longitudinal branches running down the middle of the wing; an internomedian with three or four inferior, at first rather distant, bent branches, terminating far out; and an anal furrow which is oblique and straight apically, indicating a rather large anal area.

It should be noted however that the internomedian area is entirely separated from and lies at a slightly lower level than the rest of the wing, so that it is not impossible (though not probable) that there are two wings here. Both parts are perfectly flat with brownish veins.

The length of the fragment is 5.75 mm. and its breadth 4.5 mm. indicating a wing about 12 mm. long, and perhaps 5 mm. broad. It comes from the English Purbecks and was sent me by Rev. P. B. Brodie. On the same stone, close beside the upper fragment, lies the specimen of *Diplurobląttina Bailyi* described further on and figured on Pl. 48, fig. 5.

The other (Pl. 46, fig. 13) has a broad costal area which would be rather short, but that the otherwise rather strongly arcuate main vein is reinforced apically by two or three superior longitudinal branches, while the inferior branches are numerous, simple, parallel and oblique; the externomedian vein is much as in the preceding and the internomedian has almost equally longitudinal veins, forking considerably and gently arcuate at base indicating a long anal area. The slight depression of the veins indicates an upper surface, but the surface itself is perfectly flat. There is a slight ferruginous tinge to the wing which with the blackish brown veins distinguish it quickly from the dirty light brown stone. The length of the fragment is 9 mm. and its breadth 4.25 mm., indicating a wing about 13 mm. long and perhaps 4.5 mm. broad. It was received from Rev. Mr. Brodie but without indication of locality or horizon.

Mesoblattina Bensoni sp. nov.

Pl. 46, fig. 17.

An almost perfect wing, being broken slightly at the base. It is very slender, being almost four times as long as broad and of the same shape as *M. Blakei* is presumed to be. An under surface is shown. The humeral field is moderate, extending over somewhat more than a quarter of the wing. The mediastino-scapular vein is gently sinuous near the base, beyond nearly straight, terminating just above the extreme apex and giving the costal area nearly half the wing; the veins are numerous, slightly elevated, parallel, longitudinally oblique, and in the outer half of the wing always forked to a moderate degree. The externomedian first forks opposite the end of the humeral field, and has ultimately about eight or nine branches which have a very graceful longitudinal course, scarcely arcuate downward and occupying the whole of the lower half of the wing tip. The internomedian is first forked even earlier than the preceding, and its similarly abundant and crowded branches have a very graceful and gentle, longitudinally sinuous sweep, all falling on the margin in the apical two-fifths of the wing. The anal area is ample, the furrow being very regularly arcuate, terminating near the end of the second fifth of the wing, depressed, especially in the apical half; the anal nervules of a similar abundance to those of the rest of the wing, mostly forked near their base, arcuate and parallel to the furrows.

The length of the wing is about 18.25 mm. its breadth 5.1 mm. It comes from the Upper Lias of Dumbleton, Gloucestershire, England, where it was obtained by Rev. R. L. Benson, who gave it to Rev. P. B. Brodie, to whom I am indebted for an opportunity to study it. It is of a dull fuliginous color with here and there a reddish tinge on a bluish gray stone.

Mesoblattina Swintoni sp. nov.

Pl. 16, fig. 10.

A fragment of the most important parts of a wing shows so great a resemblance to *M. Bensoni* that it can hardly be doubted that it belongs in this immediate vicinity, while its differences will scarcely allow us to place it in the same species. The general distribution of the branches of all but the anal veins (which are not preserved) is essentially that of *M. Bensoni*, even to the relative origin of the earliest forks of the externo- and internomedian veins and their relation to the humeral field; but the course of the mediastino-scapular vein (which is quite straight just where in *M. Bensoni* it is most sinuous, and gives the costal area about two-fifths of the area of the wing), and the less strongly arcuate and apically more straight anal furrow, which gives the area a greater longitudinal extent while the straightness of the superior veins lessens its breadth, give it at once a different aspect from *M. Bensoni* and renders it most probably an entirely distinct species. It is also probable that it is not so slender a species as the preceding, being probably but little more than three times as long as broad.

The fragment is 8 mm. long, and 5 mm. broad, but the probable length of the wing was about 18 mm. and its probable breadth 5.5 mm. It comes from the English Purbecks and is in the collection of Rev. P. B. Brodie. The species is dedicated to Mr. A. H. Swinton who has contributed somewhat to our knowledge of English fossil insects. It occurs on a dirty chalky-white stone, and is faintly fuliginous in color. An upper surface is shown and the wing is faintly arched transversely but is otherwise flat; the veins are channelled, the anal furrow and internomedian less than the others, but the anal furrow is not depressed below the level of the other veins.

Mesoblattina Geikiei sp. nov.

Pl. 16, fig. 9.

A [illegible] fect wing, beautifully preserved, showing an upper surface. It is slender, [illegible] than three times as long as broad. The humeral field is moderate being about as long as the width of the wing, and lancet-shaped. The mediastino-scapular vein is gently and broadly sinuous terminating a little above the very apex of the wing, making the costal area broadest in the middle and a little less than two-fifths the width of the wing; its branches are tolerably numerous, longitudinally oblique, the basal ones simple, the others which are more oblique forked about their middle. The externomedian vein forks first opposite the tip of the anal furrow, and terminates as far below the tip as the upper vein above it; it has two or three simple or forked longitudinal branches. The internomedian forks opposite the end of the humeral field and has three or four more or less longitudinally sinuous branches impinging on the outer half of the inner margin, which, like the costal branches, are less crowded on the margin than the externomedian. The anal furrow is rather deeply depressed, strongly and very regularly arcuate, terminating a little beyond the end of the basal third of the wing; the anal nervules are parallel to it, but sinuous mesially (as if by an accident of inhumation) and apically forked, terminating at equidistant points on the margin; they are about as distant as the costal branches. The whole wing, excepting in the basal half of the costal area and of course the humeral field, shows a cross venation between the nervules, breaking them into pretty regular quadrate cells.

The length of the specimen is 12.25 mm.; probable length of wing 13.5 mm.; its breadth 4.5 mm. It comes from the Lias of Brown's wood, Moreton Bagot, Warwickshire, England, and was sent me by Rev. P. B. Brodie. It is named for the present director of the Geological Survey of Great Britain. The wing, which glistens a little, is scarcely darker than the slate-gray stone on which it rests; the veins, which run in depressions (while the intercalaries keep the ridges of the roof-like interspaces) are reddish brown, interrupted frequently by obscurer portions giving them a flecked appearance under the lens; the same is true of the cross veins in the anal area.

Mesoblattina dobbertinensis.

Blattina (Mesoblattina) dobbertinensis E. Gein., Zeitschr. Deutsch. geol. Gesellsch., 1884, 570, Pl. 13, fig. 1.

Mesoblattina dobbertinensis Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 115.

This species has been described with some care by Geinitz, and needs no further mention than to say that its nearest ally appears to be *M. Geikiei*, a species twice as long; it differs from it also in the greater brevity of the anal area and the much greater breadth and importance of the costal area.

Its length is 6.5 mm. and it comes from the Lias of Dobbertin, Germany.

2. *The anal veins are directed toward the tip of the anal furrow.*

Mesoblattina Higginsii sp. nov.

Pl. 47, fig. 11.

This species and the next, of neither of which is the anal area known, are placed in his group because of their general relations to the species which unquestionably fall here, though it may readily be found hereafter that they must be transferred to the preceding group, to the latter species of which they bear many marks of resemblance, but from which they also both differ much in the immense extent of the humeral field.

A single wing with a fragmentary tip represents the upper surface of this species. It is of a dull, pale yellow color on a dirty chalky-white stone. The surface is flat, the veins depressed and slightly dusky. Restoring the form of the apex from the course of the existing margins and veins, the wing appears to have been elongate elliptical in shape, probably three times as long as broad, with uniformly and considerably arcuate costal margin. The humeral field is depressed lancet-shaped and of unusual extent, reaching certainly over one-half the wing and probably more. The mediastino-scapular vein is pretty strongly sinuous, especially arcuate a little beyond the base and terminates at the tip of the wing, the costal area occupying in the outer half of the wing fully half its breadth; the branches are longitudinally oblique, straight, parallel and not crowded, the basal ones simple, the outer forked and more longitudinal. The externomedian is closely attached to the preceding vein in the basal third of the wing, beyond that arcuate with superior, forked, longitudinal branches, the first fork opposite the end of the anal furrow. The internomedian is pretty strongly sinuous and obliquely longitudinal with three or four inferior, rather distant, arcuate branches, strongly arcuate and sublongitudinal as they approach the margin, which they touch only in the outer half of the wing; it first forks opposite the divergence of the upper veins. The anal area is very large, the furrow no more impressed than the other veins, strongly and pretty regularly arcuate, terminating, by reason of a slight outward sweep at the tip, not far short of the middle of the wing. The ultimate branches are more crowded on the apical than on the costal or inner margins.

Length of fragment, 11 mm., probable length of wing, 15.5 mm., breadth, 5.4 mm. The specimen comes from the English Purbecks, locality not stated, and was submitted to me by Rev. P. B. Brodie. The species is named for Rev. H. H. Higgins of Liverpool.

Mesoblattina Murchisoni.

Pl. 47, fig. 5.

[Without name] Westw., Quart. Journ. Geol. Soc. Lond., x, Pl. 18, fig. 43.
Rithma Murchisoni Gieb., Ins. Vorw., 319.
Blattidium Murchisoni Heer, Viertelj. naturf. Gesellsch. Zürich, ix, 290.
Mesoblattina Murchisoni Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 114-115.

Among the species with which I have been favored by Mr. Brodie is the type of Westwood's figure, and as this is defective in some particulars, I have drawn the specimen [illegible] It is in much the same state of preservation as the preceding and though nearly [illegible] is nevertheless very distinct in the sweep of the inferior veins. It shows an [illegible] nearly flat, the humeral field being a very little higher than the rest, the [illegible] slightly convex ridges. The specimen is of the same color as the dirty, [illegible] stone. Apparently no part of the inner margin is present, but the course [illegible] leads us to presume that it is straight, and the restoration of the [illegible] with the regularly arcuate curve of the costal, leads us to presume it was a little more than three times as long as broad, and, while nearly equal in width throughout, broadest in the middle. The humeral field is large, lancet-shaped but broadest shortly before its pointed tip, reaching just about to the middle of the wing. The mediastino-scapular vein is pretty strongly sinuous and especially arcuate a little beyond the base, exactly as in *M. Higginsii*, curving upwards apically and terminating before and above the tip, making the costal area broadest in the middle, where it is a little less than half the width of the wing; the nervules are exactly as in *M. Higginsii* or perhaps a little more oblique. The entire structure of the externomedian is a repetition of what is found in the last species, excepting that the basal divergence from the upper veins, is a trifle earlier and that all the nervules impinge on the apical border above, instead of all below the tip. The internomedian veins are more numerous and crowded than in *M. Higginsii*, have a more decided basal curve, and so throughout nearly their entire length are almost completely longitudinal, sub-parallel to the mediastino-scapular vein, and undoubtedly parallel to the inner margin. The anal area is tolerably large, but not so large as in the last species: the furrow, which has the character of the other veins, is strongly arcuate in the basal half, bent beyond the middle, and transversely oblique and straight beyond, terminating probably at about the end of the basal third of the wing. As stated, the anal veins are absent, and it is only presumed to belong in this section by its affinities to others and especially to *M. Bucklandi*.

Length of fragment, 11.5 mm.; probable length of wing, 13 mm.; breadth, 3.85 mm. The specimen studied is the original of Westwood's figure and comes from the Lower Purbecks of Durdlestone Bay.

Mesoblattina Bucklandi sp. nov.

Pl. 47, fig. 2.

Although a slight fragment is broken from the base and from the apex of the specimen representing this species, it is practically perfect, and though the costal margin is considerably less arcuate, it is of much the same shape as that presumed of *M. Murchisoni* with which it agrees closely in all other particulars. It shows an under surface, being concave, the anal area separately and to a considerable degree; the veins run along the top of convex ridges. The humeral field is, however, simple, lancet-shaped and only about two-fifths the length of the wing, though still extending further than the anal area. The costal area is almost a complete duplicate of that of *M. Murchisoni*, but is a little broader in the middle, almost equalling half the breadth of the wing. The externomedian vein arises in the same way but first forks a little later, just beyond the tip of the anal area, and the branches, diverging very slightly and uniformly, cover a considerable space on the margin, so as to occupy nearly all the arcuate portion of the apex below the costal area. The internomedian veins are hence a very little less longitudinal, trending slightly downward, though they strike the margin only in the apical half of the wing. The anal area is of about the same size, but the furrow, which if an upper surface were shown would be uniformly and rather deeply impressed, is almost uniformly arcuate, with no median bend, striking the margin obliquely, a little beyond the basal third of the wing. The anal veins, next the furrow subparallel to it, form as a which is a subfusiform bundle, its outer apex directed toward the extremity of the anal furrow; they seem, however, to terminate rather on the innermost vein which runs parallel to the margin, than on the margin itself. The anal area and the outer adjoining parts show a fine cross-veining breaking up the interspaces into tolerably regular quadrate cells.

Length of fragment, 10 mm.; presumable length of wing, 11 mm.; its breadth, 3.25 mm. The specimen, received through the favor of Mr. Brodie, comes from England, but its location and horizon are not indicated. It is probably from the Purbecks, and is named in memory of William Buckland. The wing is of the same color as the dull bluish gray matrix, but the veins, generally scarcely darker, are in places quite black.

Mesoblattina elongata.

[Without name] Westw., Quart. Journ. Geol. Soc. Lond., x, 394, Pl. 15, fig. 23.

Blattina elongata Gieb., Ins. Vorw., 322.

Mesoblattina elongata Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 115.

This species is too obscurely figured to enable me to describe its structure in detail, but it certainly agrees closely with *M. Bucklandi*, with which it agrees well also in size. As, however, they differ in several points of importance, I have not thought it right to consider them identical; in particular may be noted in this species the comparative brevity of the humeral field, which appears to be broken off, the abundance of the costal nervures, and the upward sweep of the median nervules.

The species is represented as 11.75 mm. long, and comes from the Middle Purbecks of Durdlestone Bay, England.

Mesoblattina protypa.

Blattina (Mesoblattina) protypa E. Gein., Zeitschr. Deutsch. geol. Gesellsch., 1880, 519–20, Pl. 22, fig. 1; Id., *ibid.* 1884, 569–70.

Mesoblattina protypa Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 114.

This species, distinguishable among its neighbors by the comparative brevity of the humeral field, the narrowness of the costal area and the straightness of the mediastino-scapular vein, has been carefully described and figured by Geinitz, and needs no further mention here.

The wing is 8.5 mm. long and comes from the Lias of Dobbertin, Germany.

Mesoblattina Murrayi sp. nov.

Pl. 17, fig. 4.

[illegible] species, known by a single example broken in the middle and lacking the tip, is [illegible] complete as to be satisfactory, and its evident relationship to the next two [illegible] that, although the anal veins are wanting, it must fall in this group. The [illegible] dingier than the dirty chalky-white stone on which it lies, the veins [illegible] upper surface is exposed and it is well arched, the veins impressed, [illegible] and when narrow, as at apex, prominent. The wing is broad[illegible] the middle, and tapers very gently owing to the arcuation of the costal margin; the tip is probably pretty fully rounded. The humeral field is well developed, well marked, flat and strongly depressed, slenderly lanceolate, extending over the basal two-fifths of the wing, the costal border delicately marginate. The mediastino-scapular vein has an entirely similar course to that of *M. Murchisoni*, making the costal area broadest in the middle of the wing, but there only two-fifths the width of the wing; the nervules are simple, rather longitudinally oblique, parallel and numerous. The base of the externomedian vein is obscured, but the branches, which are occasionally forked in the apical half of the wing, are all straight, crowded and completely longitudinal or trend slightly upward, occupying on the margin the greater, especially the upper, part of the tip. The internomedian vein first forks before the middle of the basal half of the wing, is very sinuous, the basal branches strongly bent near the outer angle of the anal area and afterwards sweeping outward with a slight obliquity. The anal furrow is not depressed, strongly arcuate, its tip slightly sinuous, reaching a little beyond the basal third of the wing.

Length of fragment, 13.65 mm.; probable length of wing, 16 mm.; its breadth, 5.35 mm. The specimen, the study of which I owe to Mr. Brodie, comes from the English Purbecks, locality not stated, and is named for the late Andrew Murray, Esq., who found time amid other valuable studies to describe the only known fossil insects of British India.

Mesoblattina Brodiei sp. nov.

Pl. 17, fig. 7.

The species is represented by an excellent specimen showing the upper surface of the wing, a little dingier than the dirty chalky-white stone on which it lies; it is slightly convex with the flat humeral field declivent, its inner border deeply impressed like the anal furrow; all the veins are impressed and of the color of the wing, those of the externomedian and internomedian areas much more faintly than the others. The wing is obovate in general form, but is of somewhat irregular shape, in which it agrees in part at least with *M. Mantelli*. The costal margin is strongly arcuate up to the tip of the humeral field, and beyond that straight to the very broadly rounded apex of the wing. The inner margin has two pretty strong and independent curves; one that of the anal area, and the other that of the remainder of the wing, where, while the curve is uniform, the effect is gained of being subparallel to the costal margin until half way to the tip, when the wing tapers somewhat by the rounded excision of the lower outer angle. The wing as a whole is about two and one-half times as long as broad. The humeral field is lanceolate, its inner border bent in the middle, its pointed tip reaching two-fifths way down the wing. The mediastino-scapular vein, parting from the humeral field at its angle, runs subparallel to, but a little divergent from, the costal margin in a very broadly arcuate curve to the tip, throwing off many parallel, oblique nervures, the basal ones of which are simple and crowded, the apical more distant, more longitudinal and forked, forming a costal area which occupies considerably more than two-fifths of the width of the wing. The externomedian vein runs close and parallel to the preceding, first forks just before the tip of the humeral field, and has three or four generally simple, inferior, sweeping, arcuate, longitudinal branches, followed by the even more arcuate, simple, apically longitudinal, internomedian branches, which arise earlier and cover an area of about equal extent. The anal furrow is strongly arcuate, being bent strongly in the middle and terminating slightly further out than the humeral field. The anal veins consist first, of two rather distant nervules subparallel and next to the anal furrow, and next, of two sets of offshoots of the inner of these, the outer of which form, with these, a subfusiform series directed toward the tip of the anal furrow, the other inner set sinuous, crowded, and apparently impinging on the basal half of the border within the anal furrow.

The length of the wing is 10.5 mm.; its breadth 4.1 mm. It comes from the English Purbecks and was kindly sent me for study by Rev. P. B. Brodie to whom I take pleasure in dedicating it.

Mesoblattina Mantelli sp. nov.

Pl. 47, fig. 9.

An almost completely preserved wing, curiously resembling and curiously different from *M. Brodiei*. The veins are of the same color as the rest of the wing, which is slightly dingier than the dirty chalky-white stone. It shows an upper surface, but is somewhat distorted by lying on an uneven surface, so that its convexity is not quite so apparent as it would otherwise be. The anal area has its independent and somewhat marked convexity, and the anal furrow, as well as the inner limit of the flat depressed humeral field, is deeply impressed. The wing is obovate with subparallel sides, but with somewhat irregular shape, the costal margin being straight from the middle of the humeral field to the middle of the outer half of the wing, and then curving strongly and pretty regularly downward to the lowermost part of the rounded apex, where it is met by the uniform and slight arcuation of the inner margin from the anal furrow outward; for the margin of the anal area has an independent arcuation, also regular but much stronger. The whole wing is a little less than three times as long as broad. The humeral field is sublanceolate, finely tapering, reaching more than two-fifths way to the wing tip. The mediastino-scapular vein is very strongly sinuate, terminating just above the tip of the wing, and the costal area is broadest in the middle of the wing where it is scarcely less than half its width; the branches are longitudinally oblique, the basal ones simple, the apical compound, arcuate, and less longitudinal than the basal. The externomedian branches, which are considerably forked apically, arise from two forked branches, which [illegible] close to their divarication opposite the tip of the anal furrow and far within the [illegible] of the humeral field; as a whole they are longitudinally and broadly arcuate. The [illegible]omedian branches, few in number and hardly forked, arise scarcely earlier and have [illegible] course, but are more strongly arcuate basally; they extend far out to the lower [illegible] of the tip of the wing, while the externomedian branches occupy the tip only. The [illegible] is strongly bent in the middle, turning sinuously outward at tip but even [illegible] extend quite so far as the humeral field. The anal nervules are obscurely [illegible] appear, as in *M. Brodiei* partly to impinge on the basal half of inner [illegible] to converge toward the tip of the anal furrow.

[illegible] is 10.1 mm. long, and 3.65 mm. broad. It comes from the English Pur-[illegible] received from Mr. Brodie. It differs from *M. Brodiei* in the form of the wing, the shape of the humeral area, the course of the mediastino-scapular vein and the character of its branches, and in the multiplicity of the apical externomedian nervules. It is named in memory of Mantell the English geologist.

Mesoblattina Hopei sp. nov.

Pl. 47, fig. 11.

The fragment of a wing representing this species lacks the apical fifth of the wing and a considerable fragment of the humeral region as well as the anal area. It shows the under surface of the wing, which is a little dingier than the dirty chalky-white stone, being uniformly concave tranversely, with the veins slightly sunken on the summits of ridges; although the anal area is gone, the furrow shows slightly prominent as a ridge. As restored in the figure, which seems to indicate its probable form, it was parallel sided, with a scarcely perceptible taper, and probably a little more than three times as long as broad, for the remains of the costal and inner margins are straight and almost parallel and the veins have a very longitudinal aspect. The mediastino-scapular vein was broadly and gracefully sinuous, plainly terminating at some distance before the tip, most of its branches somewhat longitudinally oblique and compound, the costal area being broadest at the end of the basal third of the wing, where it is scarcely less than half its entire breadth. The externomedian and internomedian veins are longitudinal beyond their base, and even, especially the externomedian, swing upward, the division between the two being probably at the very apex of the wing. The anal furrow, roundly bent very strongly before its middle, takes an oblique course beyond it, but probably does not exceed the basal fourth of the wing.

The length of the fragment is 11.25 mm.; the probable length of the wing 14.25 mm.; its width 4.75 mm. It comes from the English Purbecks, and is named for Rev. F. W. Hope who has contributed to our knowledge of fossil insects.

In this vicinity appears to fall another specimen from the English Purbecks (Pl. 47, fig. 6) which is too obscure for extended description. It is a nearly perfect wing, showing the upper surface, but being of the same color as the dirty brown stone it is hard to determine the venation excepting in the most general way. In form it appears to resemble rather closely that presumed for *M. Hopei*, except in being slenderer and having a more acuminate tip. It appears to be more than three times as long as broad, with a large, prominent, sunken humeral field; a scarcely sinuous mediastino-scapular vein, terminating probably above the apex of the wing and having numerous oblique branches, forming an area which occupies nearly half the wing; longitudinal and closely approximate parallel median veins; and a comparatively small anal area, the furrow not reaching one-fourth the way out.

Length of wing, 16.7 mm.? ; breadth, 5.5 mm.

Mesoblattina Peachii sp. nov.

Pl. 47, fig. 10.

The nearly perfect specimen which represents this species shows the upper surface of a wing, which is a little dusky on a dirty, chalky-white stone. It is gently convex with the veins delicately impressed, the anal furrow apparently no more deeply than the others. The wing is very regularly elongate elliptical in form and about two and three-fourths times longer than broad. The extreme base is broken, but the flat humeral field is apically pointed and tapering, and apparently just about as long as the width of the wing. The characters of the costal nervules are just about intermediate between those of *M. Brodiei* and *M. Mantelli*, the area being broadest in the middle, where it is very nearly half the width of the wing and extends to the exact tip of the wing. The externomedian and internomedian veins are also about intermediate between the same two species, though their terminal area is almost exactly as in *M. Brodiei*. It differs, however, from both of these species in the very regular form of the wing. The anal furrow is precisely as in *M. Hopei* and terminates on the margin just short of the tip of the humeral field.

Length of fragment, 10.5 mm.; probable length of wing, 11.6 mm.; breadth of same, 4.1 mm. It is named for Mr. B. N. Peach of the Geological Survey of Scotland, and comes from the English Purbecks.

Mesoblattina angustata.

Blattina angustata Heer, Viertelj. naturf. Gesellsch. Zürich, IX, 288, 299–300, Pl., fig. 6.

Blattina (Mesoblattina) angustata E. Gein., Zeitschr. Deutsch. geol. Gesellsch., 1880, 519–520.

Mesoblattina angustata Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 114.

This species, which is well figured and described by Heer, is conspicuous among the species of Mesoblattina for its wedge-shaped form, in which it closely resembles a Rithma. The course of the internomedian branches contends, however, against this, and besides, all the anal veins cluster apically toward the tip of the anal furrow, as often in Mesoblattina, and never, so far as known, in Rithma. The costal area occupies half the wing and the humeral field, of which Heer makes no mention, must be very small, slender and short.

Length of wing, 8 mm.; breadth, 2.5 mm. It comes from the Lias of Schambelen, Switzerland.

Mesoblattina Mathildae.

Blattina Mathildae E. Gein., Flötzform. Mecklenb., 29–30, Pl. 6, fig. 1.

This somewhat aberrant form of Mesoblattina has been wrongly interpreted by Dr. E. Geinitz, as he has mistaken the inner for the costal margin and *vice versa*. The base of the wing is broken, but the fragment seems to represent an elliptical wing, a little less than two and one-half times longer than broad, with the lower outer edge rounded off so as to bring the tip of the wing above the middle line. No trace of a humeral field can be seen, and it must be confined to the broken base and therefore short. The scapular vein (anal and part of internomedian of Geinitz) is pretty strongly arcuate in the fragment (probably with a reverse curve, so as to be sinuous at the base), terminating just above the elevated tip of the wing, broadest ... where it is more than two-fifths of the breadth of the wing, all its branches ... longitudinally oblique and parallel, the basal ones simple, the outer forked or compound. The externomedian is arcuate at base, first forking opposite the tip of the anal furrow, shortly after which the forking branches become completely longitudinal and occupy apically a very narrow portion of the extreme apex. The internomedian first forks back of the fragment and with its branches has a decidedly arcuate sweep, all the veins in the apical half of the wing being almost completely longitudinal, and impinging at subequal distances along the whole inner margin beyond the anal furrow. In this particular it rather resembles Rithma, but this is brought about by the single fact that the innermost branch, just opposite and close to the tip of the anal furrow, has a forked branch which sends three shoots to the margin close beside it, but for which, all the terminal branches would reach beyond the middle of the wing. The anal furrow is only seen near the end, where it is straight and oblique and probably strikes the margin before the end of the basal third of the wing.

Length of fragment, 18 mm.; probable length of wing, 22.5 mm.; breadth, 8.3 mm. It comes from the Lias of Dobbertin, Germany.

Mesoblattina antiqua.

[Without name] Westw., Quart. Journ. Geol. Soc. Lond., x. 395, Pl. 17, fig. 10.
Rithma antiqua Gieb., Ins. Vorw. 319.
Blattidium antiquum Heer, Viertelj. naturf. Gesellsch. Zürich, IX, 290.
Mesoblattina antiqua Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 115.

This species is peculiar for its remarkable form, the costal margin being nearly straight and the inner and apical margin strongly curved, throwing the apex of the wing far above the middle; in this respect no species but *M. Mathildae* resembles it; but the form is exaggerated in Westwood's figure from the fact that the base is wanting, which, if supplied, would probably make the wing about two and one-half times longer than broad, instead of the extreme brevity of only twice as long, as the fragment is. Marginal field and anal area are altogether wanting in the preserved portion, although it is probable that the anal furrow is shown; in which case the latter must have had a sinuous course from a strong outward curve at tip, and have terminated considerably beyond the basal third of the wing. The mediastino-scapular vein is very sharply sinuous, terminating at the elevated tip of the wing and making the costal area twice as broad (half the breadth of the wing) in the middle of the outer, as in the middle of the inner half of the wing, its branches very longitudinally oblique, the generally simple basal ones more so than the outer ones. The externomedian is much more important than the internomedian vein, occupying more than twice the area, and as much marginal space, its forking branches uniformly and rather strongly arcuate throughout, apically parallel to the outer branches of the costal area.

Length of the fragment, 7.25 mm.; probable length of wing, 9 mm.; its breadth, 3.5 mm. It comes from the Lower Purbecks of Durdlestone Bay, England. It will possibly be found to belong in Elisama.

Mesoblattina? lithophila.

Mesoblattina lithophila Germ., Acta Acad. Leop.-Carol., XIX, 222, Pl. 23, fig. 19; Weyenb., Arch. Mus. Teyl., II, 256–257, Pl. 34, fig. 2; Assm., Bericht Vers. deutsch. Naturf. I, 192.

Blattidium Beroldingianum Heer, Viertelj. naturf. Gesellsch. Zürich, IX, Pl., fig. 8.

Assmann is probably correct in referring Heer's species to the one earlier described by Germar, and it appears probable that it belongs to this genus, though no figures good enough to make it certain have yet been published, and its reference here is only by way of suggestion.

The upper wings are 16 mm. in length and the species comes from the Jurassic beds of Solenhofen, Bavaria.

ELISAMA Giebel (emend.)

Elisama Giebel, Ins. Vorw., 320; Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 113.

Although Giebel misinterpreted the neuration completely, interchanging the costal and inner margins, the species on which he founded the genus form a natural group, to which I am now able to add others; his name may, therefore, be retained. The wings are not so slender, generally, as in Mesoblattina and Rithma, and are more nearly allied to the former, but the characteristics by which that is distinguished from Rithma are here intensified. In none of the species known to me are there any specimens in which the base is completely preserved, but what remains are preserved show, without reason for doubt, that the wings are most peculiar in this very region. There is no sign in any of them of any separate humeral field, so characteristic of Rithma and Mesoblattina, and if it existed it must have been very slight. The anal area is also exceptionally small and unimportant, rarely extending a fifth way down the wing and having a very slight breadth, the anal furrow appearing to be either straight or bent in a sense the reverse of usual, taking rather the direction of the anal angle of the wing. In consonance with this, the median branches and especially the internomedian are more sharply bent than even in Mesoblattina (though some species of the two genera agree fairly well here) and fill the inner half or more of the wing with longitudinal veins, so that this region is in marked contrast to the costal with its oblique branches. The median branches seem to be always numerous, and, excepting in one instance, do not reach the border before the distal half of the wing.

The genus is tolerably abundant in species, most of which are found in the English Purbecks; one, however, doubtfully referred here, belongs to the Swiss Lias.

Elisama Molossus.

Elisama Molossus Westw., Quart. Journ. Geol. Soc. Lond., IX, 384, 394, Pl. 15, [illegible]

Nethania Molossus Gieb., Ins. Vorw., 321.

Giebel founded the genus Nethania upon this single species, upon characters drawn from the supposition that the oblique veinlets were those of the anal, while they are really those of costal area, the margins of the wing having been interchanged in his conception of it. The genus Nethania then might be allowed to drop out of sight, even if it did not appear that the species in question should fall into the same genus as the species referred by him to Elisama, in the conception of which, as pointed out above, he made an exactly similar error. The species seems in fact to fall next to *E. Kneri*, having a very similarly arcuate mediastino-scapular vein, terminating, probably, higher than there, and a similar sweep and manner of forking of the median veins, and, besides, a spot near the base of internomedian area (but farther out than in *E. Kneri*) apparently made up of numerous cross veins; but the basal sinuation of the main vein is much greater than is possible in *E. Kneri* and the basal arcuation of both externomedian and internomedian nervules, especially the latter, is so much less marked, so comparatively slight indeed, that it was not at first recognized as a member of this group, of which indeed it must be looked on as a rather aberrant form.

Length of fragment, 8 mm.; probable length of wing, 10.5 mm. The breadth is too uncertain in the figure to give any definite statement. The specimen comes from the middle Purbecks of Durdlestone Bay, England.

Elisama Kneri.

Pl. 17, fig. 1.

[Without name] Brodie, Foss. Ins. Engl., 118, Pl. 5, fig. 1.
Elisama Kneri Gieb., Ins. Vorw., 320.
Blattidium Kneri Heer, Viertelj. naturf. Gesellsch. Zürich, IX, 291.

I have received from Mr. Brodie the original of his illustration, of which I give a new figure showing the wing to be less complete than his plate would lead one to suppose. Only about half the wing remains, but this the most important part, more than a third, probably, of the tip being broken off, and a not unimportant part of the base. The straight, scarcely divergent costal and inner margins of the fragment indicate, with the neuration, a form like that restored, which, if correct, would make the wing about two and one-third times longer than broad and broadest just beyond the middle. The mediastino-scapular vein has a very strong arcuation, strongest on the basal side, since beyond, by successive forks, it loses the strength of its arcuation and is probably carried to the very tip of the wing; the greatest width is before the middle of the wing, where the costal area is considerably more than two-fifths the breadth of the wing; the basal branches are simple and oblique, those beyond forked or compound and increasingly longitudinal. The externomedian branches are all superior, the internomedian all inferior, but all take a common arcuate sweep so as to be longitudinal in the middle of the wing, and the former probably occupy on the margin only the lower half of the tip. Between all the veins which reach the margin are intercalaries, and where the internomedian nervules commence to become longitudinal, *i. e.*, just where the lowermost approaches the border, they are obscured by a large roundish fuscous spot, which nearly crosses the entire field. The anal furrow and anal area are lost in the broken base of the wing, but must have [illegible] small. An under surface is exposed on the dirty light brown stone, scarcely darker than the stone itself, with veins and intercalaries black; the surface is almost perfectly flat, only a slight concavity being discernible, and the veins are elevated in the slightest possible degree.

The length of the fragment is 8.5 mm.; probable length of the wing, 13.5 mm.; its breadth, 5.75 mm. The specimen comes from the Purbecks of Wiltshire, England.

Elisama minor.

Pl. 47. fig. 13.

[Without name] Brodie, Foss. Ins. Engl., 118, Pl. 5, fig. 20.
Elisama minor Gieb., Ins. Vorw. 320.
Blattidium minor Heer. Viertelj. naturf. Gesellsch. Zürich, IX, 291.

A specimen received from Rev. Mr. Brodie seems to me to represent pretty certainly the original of his illustration of this species (represented, as usual, reversed on his plate). But even if it is not, it certainly belongs to the same species, and its examination shows that, as in the single specimen of *E. Kneri*, the base is badly broken, and about a quarter of the tip lost; nevertheless the most important part of the neuration remains and enables us to restore the wing with considerable confidence, by which it would appear to be nearly two and one-half times longer than broad and to have had a more convex costal margin than *E. Kneri*. An under surface is exposed, of the same color as the dirty brown stone on which it lies, with black or blackish brown veins and intercalaries. The surface is flat or scarcely concave, the veins scarcely elevated, and the intercalaries slightly sunken. The mediastino-scapular vein is moderately and very regularly arcuate throughout, terminating probably just above the extreme tip of the wing, its branches quite as in *E. Kneri;* the width of the costal area, which is broadest just before the middle of the wing, is here scarcely less than half that of the wing. The externomedian and internomedian branches, by a strong arcuation at base, almost immediately take on a longitudinal and parallel course, filling the space below with very straight veins, those of the externomedian occupying apparently a very narrow space on the extreme tip of the wing. On their basal half or third, farther out next the inner margin than above, these veins are crossed by numerous cross veins, and in the same place as in *E. Kneri* is a pretty large roundish dusky patch. There are intercalaries between all the veins. The anal furrow, which is perfectly flat, is bent in the middle at a [illegible] angle in the same direction as the inner angle of the wing.

The length of the fragment is 5.5 mm.; the probable length of the wing 7.75 mm.; breadth 2.1 mm. The specimen comes from the English Purbecks and bears also the [illegible] "B[illegible]," probably the collector.

Elisama Bucktoni sp. nov.

Pl. 47, figs. 8, 12.

T[illegible] submitted to me by Mr. Brodie, represent this species, neither of [illegible] quite perfect, and one with about one-fifth broken from the tip.

Both of them show the upper surface transversely, slightly and regularly arched, with the delicate veins impressed sharply and slightly in the basal half of the wing, while in the apical half they run as slight ridges at the bottom of flattened furrows between slight, rounded ridges, the ridges scarcely narrower than the furrows and the passages from one to the other being gradual. One of them, fig. 12, is of the same color, veins and all, as the dirty light brown stone, and has the anal furrow a little more deeply impressed than the other veins; the other, fig. 8, is slightly discolored and rests on a dirty chalky-white stone, and the anal furrow is obscure, although apparently impressed no more deeply than the others; where the costal border of this specimen is best preserved it is seen to be narrowly margined. The wings are somewhat more than two and one-half times longer than broad, are broadest just before the middle of the basal half, beyond which they taper very slightly and regularly to about the middle of the apical half, when, especially by the rounded excision of the inner margin, they narrow much more rapidly and terminate in a somewhat pointed shape, the apex above the middle line of the wing; along most of their course both costal and inner margins are straight or very nearly straight. The mediastino-scapular vein is very broadly and pretty uniformly arcuate, terminating just above the extreme apex of the wing, and, excepting two or three simple ones close to the base, all the branches are arcuate, parallel, oblique and strongly compound, so that comparatively few originate directly from the main stem, while a very large number of crowded nervules reach the margin; at its extreme breadth, about the middle of the wing, the costal area occupies a little more than two-fifths the width of the wing. The externomedian and internomedian veins are broadly sinuous, being almost longitudinal in the middle, pretty strongly arcuate in one sense next the base, and gently arcuate in the opposite next their pretty uniformly forking tips where they curve downward to strike the margin, the externomedian terminating upon the apex and extreme apical end of the inner margin, the internomedian beyond the middle of the inner margin. The anal furrow is a straight oblique line, apparently curving downward at extreme tip, in one specimen (fig. 12) terminating at no further than one-fifth of the way from the base, and leaving necessarily an extremely small anal area.

Length of one specimen (fig. 8) 10.6 mm.; breadth 4 mm.; of the other (fig. 12) 8 mm.; probable length of wing 10.1 mm.; breadth 3.75 mm. Both specimens come from the English Purbecks; the species is named for Mr. G. B. Buckton, who, in a recent monograph of British Aphides, has not neglected the fossil species, whether British or foreign.

Elisama Kirkbyi sp. nov.

Pl. 47, fig. 3.

A wing from which the base and one-third of the tip are lost represents this species, which nevertheless plainly belongs in this genus and is very distinct from the other species, the neuration being so regular that it could be restored in the missing apical portion with high probability of accuracy, though the form of this part is more conjectural. As restored, the wing was probably rather more than two and one-half times longer than broad. It represents an under surface, being uniformly concave, and is of the same color, veins and all, as the dirty, chalky-white stone on which it rests, the veins being slightly depressed on the summits of rounded ridges separated by transversely rounded furrows. The mediastino-scapular vein is straight in the basal half of the wing; beyond curves slightly and probably terminates a little above the tip with, so far as can be seen, only simple or basally forked, parallel, oblique, scarcely sinuous branches, the costal area being slightly less than two-fifths the breadth of the wing. The externomedian and internomedian veins are strongly arcuate at the extreme base; beyond completely longitudinal in the externomedian area, probably terminating in a narrow space at the extreme tip of the wing, and the same, but slightly declivous, in the internomedian area, where from this cause they terminate along the entire inner margin, even within the basal half of the wing; in the median areas, the interspaces are generally seen to be broken by dull cross veins into quadrate cells, but near the middle of the wing both veins and cross veins are effaced by imperfect preservation. The anal furrow is transversely oblique with no distinction of impression and must terminate at a very short distance out. The species is remarkable for the straightness and simplicity of its costal area, the early termination of its earlier internomedian nervules and its uniform breadth.

Length of fragment, 7.5 mm.; probable length of wing, 14 mm.; breadth, 4.5 mm. The specimen was received from Rev. Mr. Brodie, as from the English mesozoic beds, but without further indications. It is named for Mr. J. W. Kirkby, who has made us acquainted with some of England's earliest fossil cockroaches.

Elisama ? media.

Blattidium medium Heer, Viertelj. naturf. Gesellsch. Zürich, IX, 289, 300, Pl. fig. 7.

An obscure and imperfect specimen, which agrees better with this genus than any other and probably belongs here and to a species distinct from any others known, being distinguished for its tapering form, its straight inner margin, while the costal margin is convex, the regular narrowing of its costal area, which is broadest close to the base and which probably terminates at the very upper extremity of the apex, its intercalary veins and the complete longitudinality and straightness of its median veins.

Length of fragment, 8 mm.; probable length of wing, 10.25 mm.; breadth, 3.5 mm. It comes from the Lias of Schambelen, Switzerland.

b. The externomedian vein of the upper wings is amalgamated either with the scapular or with the internomedian, and all other veins are independent.

PILEINOBLATTINA Scudder.

[illegible] Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 105.

[illegible] ssil cockroaches figured by Westwood thirty years ago, was one which [illegible] amed *Blatta pluma*, on account of the resemblance of its neuration [illegible] feather, with the shaft on one side. Several species are now known, [illegible] d as an hemipteron by Germar nearly fifty years ago, and on account of this curious arrangement of the veins, I proposed recently the generic name here employed. The wings are very broad, expanding considerably beyond the base, broadest beyond the middle, and filled with an abundance of branching veins. The mediastinal, scapular and combined externomedian and internomedian veins run close together, side by side, in a perfectly straight course (the shaft of the feather) from near the middle of the base of the wing toward and nearly to a point on the costal margin a little within the apex of the wing, and the superior mediastinal and scapular and inferior externomedian and internomedian branches, crowded closely together, part from this apparently common stem at nearly similar angles on either side of it; while the anal area, at least where known, occupies a considerable and nearly equal band along a considerable portion of the inner margin, running into and often strongly interfering with the internomedian nervules. As stated in the introductory portion of this paper, what was formerly regarded by me as internomedian is now looked upon as unquestionably anal, so that we can only interpret the neuration by supposing the externomedian and internomedian veins to be amalgamated, and this will remove the genus from the Palaeoblattariae.

The genus was tolerably prolific in species, which vary greatly in size, the two species from the middle Oolite of Solenhofen being particularly large, while one of the Liassic species from Germany is one of the smallest of mesozoic cockroaches. Four species (including two doubtfully referred here) are known from the middle and lower Purbecks of England, two from the middle Oolite of Bavaria and three from the Lias, one in Germany and two in England.

Pterinoblattina pluma.

Pl. 18, figs. 7, 8°.

[Without name] Westw., Quart. Journ. Geol. Soc. Lond., x, 384, 394, Pl. 15, fig. 11 (2 figs.)

Blatta pluma Gieb., Ins. Vorw., 322.

Pterinoblattina pluma Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 105-106.

The specimen, the original of which I have had the privilege of studying, by the favor of my kind friend Rev. P. B. Brodie, is rather imperfect, and a little deceptive from the fact that just that portion of the tip is missing which contains the scapular branches: it is probable, however, from the longitudinal character of the apical offshoots of the median vein that the species more closely resembles *P. chrysea* than *P. intermixta*. There is no discoloration of the stone to mark the wings, though the veins are pale; no portion of any margin is preserved; it lies flat upon the stone, but the scapular vein is slightly depressed while the others with their branches are slightly elevated, by which it would seem that the under surface were uppermost. All the mediastinal branches are simple, parallel, equidistant, almost straight, closely crowded, and part from the main stem at an angle of about 45°. The median branches, the only others preserved, part at a less angle, gradually become quite horizontal apically, are nearly as close at base as the scapular branches, and as most of them fork and even re-fork, though with entire irregularity, become excessively crowded toward the margin.

The length of the fragment is 9 mm., its breadth 5 mm. Probably the wing was 12 mm. long, and 5.5 mm. broad. It was found in the Corbula or Pecten beds of the middle Purbecks of Dorset, England.

Pterinoblattina penna.

Pl. 48, fig. 14.

Pterinoblattina penna Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 106.

The single specimen of this species at hand is preserved in much the same manner as the last, but shows a fragment of the anal region. The specimen is of the same color as the dirty chalky-white stone on which it rests. The median area is scarcely concave, the vein depressed; the mediastinal area is slightly convex and its main stem is elevated above the two next below it. The three principal veins approach each other very gradually so as to give them the appearance of a tapering rod. The mediastinal branches part from the stem at nearly a right angle near the base of the wing, gradually increasing in obliquity distally, until they form an angle of 45° with it; they are slightly curved, the concavity outward, very closely crowded, and about every third one forked near the middle, but with no regularity. The scapular branches are not preserved, but as in ***P. pluma,*** and for the same reason, they probably resemble *P. chrysea* rather than ***P. intermixta.*** The median branches are very closely crowded, generally straight, part from the stem at an angle of 15° next the base, and become almost wholly longitudinal at the apex; they fork about as frequently as, and more irregularly than, the mediastinal branches. The anal area extends far out on the wing, and its branches (what few can be seen) resemble those of the preceding area, and at its extremity are parallel to them.

Length of fragment, 13 mm.; width, 9 mm. Probable length of wing, 15 mm.; probable width, 9 mm. Described from a specimen from the English Purbecks sent me for examination by Rev. P. B. Brodie.

It is not impossible that the fragment of a larger wing figured without name by Westwood (Quart. Journ. Geol. Soc. Lond., x, Pl. 17, fig. 7), from the Lower Purbecks of Durdlestone Bay may be a species very close to this, if indeed it is not the same.

Pterinoblattina chrysea.

Blattina chrysea Gein., Zeitschr. Deutsch. geol. Gesellsch., 1880, 520, Pl. 22, fig. 2.
Pterinoblattina chrysea Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 106–107.

In this case we have a more perfect wing, the tip being almost completely preserved. The mediastinal vein terminates before the middle of the outer half of the costal border, [illegible] furnished with simple, straight, oblique branches, not so numerous as in the other [illegible], to judge by the figure, though they are spoken of by Geinitz as "very numerous [illegible] crowded." Just before the scapular reaches the tip of the mediastinal, it [illegible] to the costal margin, runs to the upper tip of the wing, and emits branches [illegible] of the mediastinal, but of course of equal length. All the median [illegible] almost longitudinally, are straight, sometimes forked, and appear from the figure to be less crowded than the mediastinal branches, though they are compared by Geinitz to the barbs of a feather. The anal runs to just beyond the broadest part of the wing, being thus longer than the mediastinal, and sends less crowded, gently curved, usually forked, rather short branches to the border. The few anal branches curve and strike the inner margin.

Length, 5 mm.; breadth about 2.25 mm. From the Lias of Dobbertin, Germany. The description is drawn up from the data given by Geinitz.

Pterinoblattina Curtisii sp. nov.

Pl. 48, fig. 16.

The fragment of only a tip of a wing represents a species apparently about midway between *P. chrysea* and *P. intermixta*, approaching the latter in delicacy and multiplicity of its crowded neuration, the former in the disposition of the scapular vein and its branches. It is independent of both in the pointed, almost falcate shape of the tip of the wing. The scapular and median veins and branches are the only ones preserved. The former runs parallel to, and at but a short distance from, the declivous curve of the outer part of the costal margin and sends frequent, longitudinally oblique, apically forked branches to the margin, ending at the extreme pointed tip of the wing. The median veins are numerous, straight, parallel to each other and to the apical portion of the scapular vein, and forked pretty uniformly when about as far from the margin as the width of the scapular area.

The length of the fragment is 19 mm.; probably the wing was of twice this length. It comes from the Upper Lias of Alderton, Gloucestershire, England, and was received from Rev. P. B. Brodie. It is named for one of the first English naturalists who interested himself in fossil insects.

Pterinoblattina intermixta.

Pl. 48, fig. 9.

Pterinoblattina intermixta Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 107–108.

A nearly complete wing of this species has almost the same shape as *P. chrysea*, but the upper part of the apex is more produced, though not at all pointed as in *P. Curtisii*. The mediastinal vein terminates before the middle of the outer half of the wing, and the area narrows more gradually than in any of the others; its branches are gently curved, and often forked, but not excessively crowded. Just before reaching the tip of the mediastinal, the scapular vein suddenly bends toward the apex, running subparallel to, but away from, the costal margin, terminating at the tip and emitting a crowd of curved and forked branches. The closely crowded median branches part at an angle of 15° with the stem, are straight, and fork only just before the tip, forming a tolerably regular belt of crowded veinlets along the margin. The basal branches, however, are interfered with and affected by the anal vein, which is nearly straight, at first running plump against the median branches, curves then downward parallel to these and terminates a little before the mediastinal; it is furnished abundantly with branches curving like its extremity and [illegible] the border like the median branches, but where it abuts against these latter, [illegible] the appearance of the anal branches so as to appear as if a part of the [illegible] and thus give the latter the appearance of extending out beyond the broadest [illegible] wing. The specimen is of a slightly glistening, dark brown color on a dirty [illegible], the veins and all the nervules sharply though only slightly impressed, while [illegible] wing is at a dead level.

Length of fragment, 10.5 mm.; probable length of wing, 12 mm.; breadth, 5.75 mm. Received from Rev. P. B. Brodie, as coming from the Upper Lias of Alderton, Gloucestershire, England.

Pterinoblattina hospes

Ricania hospes Germ., Acta Acad. Leop.-Carol., XIX, 220–21, Pl. 23, fig. 18.
Pterinoblattina hospes Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 108.

Germar took this for one of the Fulgorina, in the neighborhood of Ricania and Poeciloptera. Assmann thought it a neuropteron, falling in the neighborhood of Drepanopteryx. It is pretty plain, however, that it belongs here, though the figure given by Germar is not sufficiently clear to enable one to formulate any characteristics. It would seem, however, that the scapular vein probably terminated on the costal margin some way before the tip, and that the latter is shaped much as in *P. intermixta*, and occupied by median branches only; these are more oblique and the lower outer angle much less prominent than in *P. intermixta*, while in the present species the anal angle is prominent and the anal area extended by that alone, occupying a very oblique equal basal band.

It comes from the Oölite of Solenhofen, and measures about 25 mm. in length and 13.5 in breadth.

Pterinoblattina gigas.

Ricania gigas Weyenb., Arch. Mus. Teyl., II, 270–71, Pl. 35, fig. 23.
Pterinoblattina gigas Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 108.

Following Germar, Weyenbergh placed this enormous species in Ricania, but it evidently falls here and bears a close general resemblance, excepting in size, to *P. penna* of the Purbecks. It differs from *P. hospes*, which it most resembles, in the greater extent of the scapular area, which nearly reaches the tip, and in the farwider extension [illegible] protrusion of the anal angle.

It measures 60 mm. long and 35 mm. broad, and comes like the last from the Oölite of S[illegible], Bavaria.

Pterinoblattina? Sipylus.

[illegible] Westw., Quart. Journ. Geol. Soc. Lond., x, 390, 396, Pl. 18, fig. 24.

[illegible] sidered this to represent "a wing of an insect allied to Sialis," while of [illegible] *P. Binneyi*, he says it appears "to be orthopterous." An exami[illegible] wings here ranged under the name of Pterinoblattina will convince [illegible] proximity to them of these two abnormal wings; in their elongated [illegible] ly different, and were they certainly comparable as front wings they should be separated generically; but their close resemblance in neuration, which is at the same time in most parts of the wing less dense, leads me to suspect that they may really be hind wings of species of Pterinoblattina of a more elongate form than any yet known (the species vary considerably in this direction), and that for this reason it may be well at least for the present to place them here, doubtfully. The wing referred to the present species is between three and four times longer than broad, subequal, tapering to a somewhat pointed but rounded tip, the latter on the middle line. The scapular branches succeed the mediastinal, in a common, equal, narrow band, which follows the costal margin to just below the tip; the anal area, in a broader, apically tapering band, with much more distant nervules, reaches to the middle of the outer half of the wing; while the long and sinuous, basally distant, apically crowded and forked median veins occupy the intervening space.

Length of fragment, 21.5 mm.; probable length of wing, 24 mm.; breadth, 6.6 mm. It comes from the lower Purbecks of Durdlestone Bay, England.

Pterinoblattina? Binneyi.

[Without name] Westw., Quart. Journ. Geol. Soc. Lond., x, 390, 396, Pl. 18, fig. 12.

This wing has the same general form and proportions as *P. Sipylus* excepting that the extreme tip of the wing is next the lower margin and not on the middle line, but the scapular area still holds the same relation to it as in that species, bending downwards and embracing it. The anal area is more uniformly tapering and does not extend quite so far, giving ampler space for the median nervules, which appear (they are not so exactly delineated) to have the same character as in *P. Sipylus*. It is a considerably smaller species.

Length of fragment, 10.5 mm.; probable length of wing, 12 mm.; breadth, 3.75 mm. Lower Purbecks of Durdlestone Bay, England. Named for Mr. E. W. Binney.

BLATTIDIUM Westwood (restr.).

Blattidium Westwood, Quart. Journ. Geol. Soc. Lond., x, 391, 396, without description; Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 111–112.

Westwood designated four of the considerable number of mesozoic cockroaches which he figured in 1850 by the name of Blattidium. One of these, *B. Molossus*, was afterwards taken by Giebel as the type of his Nethania, based on an entirely wrong conception of the neuration, and which, as we have seen above, falls properly into his genus Elisama. A second species, *B. Achelous*, is probably neuropteroid, and will not be considered here. The other two form a second very peculiar type of cockroaches, quite as strange as Pterinoblattina, though very different from that, both from their long, slender and parallel-sided form, and from the union of the externomedian and scapular veins for nearly half their length. The mediastinal vein terminates not far from the middle of the wing, and sends out a multitude of crowded offshoots to the margin. The united scapular and externomedian vein runs parallel to the border, to which, as well as to the mediastinal vein before it terminates, it sends rather distant, oblique veins, besides an inferior longitudinal branch, which has several very distant, inferior, equally longitudinal offshoots. The internomedian vein is wholly longitudinal, and has few distant branches; these apparently terminate only in the apical border, while the main anal vein, longitudinally oblique, extends nearly as far as the mediastinal, and the outer half of the inner margin of the wing seems to have no veins falling on it; the veins of the anal area run obliquely from the margin upward and outward to the main anal vein.

The two species known come from the Lower Purbecks of England.

Blattidium Simyrus.

Pl. 48, fig. 17.

[Without name] Brodie, Foss. Ins. Engl., 118, Pl. 5, fig. 19.
Blattidium Simyrus Westw., Quart. Journ. Geol. Soc. Lond., x, 390, 396, Pl. 18, fig. 33.
Gryllidium Oweni Westw., Quart. Journ. Geol. Soc. Lond., x, 387, 395, Pl. 17, fig. 19.

The figure here given is made up from two specimens, obverse and reverse, of the type of Westwood's *B. Simyrus*, which Mr. Brodie has kindly sent me. The mediastinal area is slightly lower than the rest of the wing and the mediastinal vein deeply depressed. The species is peculiar for the fineness and irregularity of the mediastinal nervules, which are in strong contrast to the distant and regular scapular superior branches, and these in their direction and brevity to the dozen longitudinal veins belonging to the median series. The anal area is filled with oblique transverse veins having the same direction and about the same distance apart as the superior scapular nervules. An inferior marginal vein borders the under surface of the wing.

Length of fragment, 25 mm.; possible length of the wing, 42 mm.; breadth, 6.5 mm. It comes from the Lower Purbecks of Durdlestone Bay.

It seems highly probable that *Gryllidium Oweni* Westw., which comes from the same place and is of the same size, is a specimen of the same species, in which the subordinate nervules of the mediastinal and anal areas are not preserved; the latter are not delineated in Westwood's figure of this species. Brodie's Pl. 5, fig. 19, which Westwood took to be the folded hind wing of a cricket, seems also probably to fall here, though it may indicate another species in which the superior scapular branches are as crowded as the mediastinal.

Blattidium Nogaus.

Blattidium Nogaus Westw., Quart. Journ. Geol. Soc. Lond. x, 390, 396; Pl. 18, fig. 23.

I have not seen this species, which has a proportionally much broader mediastinal area, [illegible] a smaller number of median veins than the other. The wing could hardly [illegible] excessive slenderness of the other species, the fragment being 18 mm. long [illegible] d, and the whole wing probably not more than 27 mm. long. It too comes [illegible] Lower Purbecks of Durdlestone Bay, England.

c. The mediastinal and scapular veins of the upper wings are amalgamated, and in addition the externomedian vein is amalgamated either with the foregoing or with the internomedian vein.

NANNOBLATTINA gen. nov. ([illegible])

In this genus, where all the wings are minute, the externomedian springs from the united mediastino-scapular vein in the second quarter of the wing. The costal field is very broad, while the internomedian area is considerably restricted in width, though it extends a good distance toward the tip. In other respects the different species vary widely. The three species come from the upper Oolite of England.

Nannoblattina similis.

Corydalis —— Brodie, Foss. Ins. Engl., 119, Pl. 5, fig. 2.
Blattina similis Gieb., Ins. Vorw., 318.

In this species the mediastino-scapular area is regularly arched on either side of the middle of the wing and occupies at most more than half its width, while the externomedian originates nearer the base than in the other species, and leaves a nearly uniform narrow internomedian area.

Length of fragment (from which a small part of the base only appears to be broken) 5 mm.; breadth 2 mm. It comes from the English Wealden.

Nannoblattina Prestwichii sp. nov.

Pl. 48, fig. 3.

A nearly perfect wing, but with the anal area lost and the basal part of the costal area. It is possible, however, to restore the missing border with a considerable degree of precision, and so to judge that the wing was tolerably slender, a little less than three times as long as broad, with straight margins, scarcely tapering, the tip well rounded. The mediastino-scapular vein is well arched, so that in them iddle of the wing the area occupies nearly half the width; most of its nervules are straight, oblique and simple, but some of the apical ones are forked. The externomedian vein parts from this in the middle of the basal half of the wing, and with its forks occupies nearly the entire tip of the wing. The internomedian is rather strongly sinuous, its area narrow excepting at extreme base, the nervules few, simple, slightly sinuous and longitudinally oblique. The anal furrow is pretty regularly and not very strongly arcuate, terminating beyond the middle of the basal half of the wing. An upper surface is exposed on the light brown stone, but it is perfectly flat; it is a little fuliginous, with blackish brown veins which are just perceptibly impressed, the anal furrow no more than the rest.

Length of fragment 6 mm.; probable length of wing 6.5 mm; breadth 2.25 mm. The specimen comes from the English Purbecks and was studied by the favor of Rev. P. B. Brodie. It is named in honor of the veteran English geologist.

Nannoblattina Woodwardi sp. nov.

Pl. 48, fig. 6.

This minute species is represented by a single nearly perfect wing, broken obliquely across the base. An under surface is exposed on the dark greenish gray stone, as appears from its slight concavity, and the prominent veins; the wing is fuliginous and the stout veins broadly marked in black. The wing is comparatively broad, the costal and inner margins straight and parallel, the tip broadly rounded, the apex slightly above the middle. The mediastino-scapular vein runs in an obliquely and gently sinuous course, terminating below the apex and broadest in the whole apical third of the wing, where it occupies fully half of its width, furnished with considerably arcuate, rather numerous, parallel, simple, oblique branches. The externomedian vein arises from this in the middle of the second fourth of the wing and is but once forked, near the tip. The internomedian vein is strongly sinuous, the area rapidly narrowing and the branches very few, short and somewhat divergent. The anal furrow is scarcely or not at all more distinct than the other veins, is strongly arcuate and must enclose a very large anal area, but the broken wing will not allow us to determine how much; it is probable, however, that it reaches nearly to the middle of the wing; the anal veins are simple, parallel, impinge on the margin, the basal ones turned apically a little outward.

Length of fragment 3.75 mm.; probable length of wing 4.1 mm.; its breadth 1.6 mm. It comes from the Wiltshire Purbecks, was received through Rev. Mr. Brodie and is named for Dr. Henry Woodward who has introduced to us so much of the life of the past.

DIPLUROBLATTINA gen. nov. (δίς, πλευρόν)

In this genus the externomedian vein has become completely amalgamated, not with the mediastino-scapular but with the internomedian. The humeral field again appears and, notwithstanding the amalgamation mentioned, the mediastino-scapular area occupies a very large share of the wing, which is of a tapering, cuneiform shape in the only species known. The veins are, therefore, branches of two principal stems which pass down the middle of the wing side by side, but as distant as the principal branches from each other.

The single species comes from the English Purbecks.

Dipluroblattina Bailyi sp. nov.

Pl. 48, fig. 5.

A [illegible]ly perfect wing represents this species in which the anal area only is wanting, [illegible] minute fragment of the tip. It has a tapering, graceful form, both costal and [illegible] being similarly and gently arcuate and the slender tip being well rounded. A [illegible] flattened humeral field, lanceolate in shape, extends over about a third of [illegible] The mediastino-scapular, strongly arcuate near the base, runs in its apical half [illegible] the middle of the wing, terminating scarcely above the tip; its rather [illegible]es, simple at first, beyond simple or forked, are oblique and tolerably straight. The median vein runs parallel to the preceding throughout, has four inferior branches arising tolerably near together just before the middle of the wing, which are very strongly arcuate, simple or forked, apically longitudinal; in the apical third of the wing, distant in origin from the preceding, are a couple of simple longitudinal branches. The anal area cannot extend beyond the basal fourth of the wing.

Length of fragment 6.75 mm.; of wing restored 7.5 mm.; breadth 2.65 mm. The wing, which is scarcely dingier than the chalky-white stone on which it rests, showing its upper domed surface with the slightly dusky veins minutely depressed, is faintly and very delicately reticulated in the basal half. It comes from the English Purbecks, lies side by side with the Mesoblattina figured on Pl. 16, fig. 3, and was received from Rev. P. B. Brodie. It is named for Mr. W. H. Baily who has interested himself in some of the fossil insects of Ireland.

DIECHOBLATTINA gen. nov. ( )

This genus is nearly allied to the last, all the veins of the wing being dependencies of two stocks, which as there pass down the middle of the wing, the veins diverging in opposite directions; but here these main stems are very closely approximated and appear to terminate before the tip of the wing, leaving the longitudinal branches only to run to the tip. The humeral field also is wanting. All the branches, as a mass, are arcuate, the superior ones with the arcuation opening toward the basal half of the costal border, the inferior toward the apical half of the same.

The two species are found in the English Purbecks.

Diechoblattina Ungeri.

[Without name] Westw., Quart. Journ. Geol. Soc. Lond., x, 395, Pl. 17, fig. 13.
Blatta Ungeri Gieb., Ins. Vorw., 322.

This minute species has much the appearance of a feather. The two main stems run close together in a regular gently arcuate course nearly to the tip, the arcuation opening toward the costal margin.

Length of wing, 5.5 mm.; breadth, 2.5. Lower Purbecks of Durdlestone Bay.

Diechoblattina Wallacei sp. nov.

Pl. 48, fig. 1.

Restoring the wing at its broken base, as in the figure, the approximated stems are seen to run in a straight, scarcely oblique course through the basal third of the wing, beyond which, in more delicate shape, they are regularly and considerably arcuate, terminating in the middle of the very broadly rounded tip. Most of the nervules are simple, the superior ones rather more crowded than the more strongly arcuate and more longitudinal inferior ones, and those arising in the apical half of the wing usually more or less forked. The costal margin is very gently convex, and the apex of the wing roundly docked; anal area broken off.

Length of fragment, 8 mm.; probable length of wing, 9.75 mm.; breadth, 4 mm. The specimen is of the same color as the dirty, chalky-white stone on which it is preserved and is apparently the under surface, the veins being slightly raised; the principal veins are scarcely separable near the base. The species, sent me by Mr. Brodie, comes from the English Purbecks and is named for the English naturalist, Mr. A. R. Wallace, whose studies have embraced fossil insects.

Scutinoblattina Scudder.

Scutinoblattina Scudd., Proc. Acad. Nat. Sc. Philad., 1885, 110.

The tegmina are more or less coriaceous obscuring somewhat the neuration. The mediastino-scapular vein is nearly or quite straight, terminating a little below the tip of the wing, while the median vein (the externomedian and internomedian being united) runs parallel to and somewhat distant from it. The anal veins fall sometimes on the inner margin and sometimes on the anal furrow. All the species are from the American Trias.

The three species are *S. Brongniarti*, *S. intermedia* and *S. recta*, all found at Fairplay, Colorado. They have been briefly described in the Philadelphia Academy's Proceedings, and will be fully discussed and figured in a paper devoted to this Triassic locality, so that it is only necessary here to indicate their position in the series.

Legnophora Heer.

Legnophora Heer, Viertelj. naturf. Gesellsch. Zürich, IX, 297.

Heer gives this name to an object of whose animal nature he was not wholly convinced. If, as he supposed, the front wing of a cockroach, it differs from all known forms in the parallel and longitudinal course of the veins of the costal area. Apparently it falls near this place, and the wing itself appears to have been somewhat coriaceous.

The single species is *L. Girardi* Heer (*loc. cit.*) fig. 5, from the Trias of Trebitz, Germany.

Aporoblattina gen. nov. (ἄπορος).

Under this name, I group a series of wings, of three of which I have seen specimens, which appear to me to be in all probability hind wings of cockroaches. They differ considerably among themselves, but agree in having the mediastinal and scapular veins distinct, the former occupying a narrow belt with longitudinally oblique veins, and in having [illegible] extensive development of the internomedian vein, with long, sweeping, arcuate [illegible] the externomedian, in all cases but one or two, where it appears to be either [illegible] or amalgamated with the internomedian, being very slenderly developed [illegible] narrow area.

[illegible] species come from the upper Oölite of England, but three species come [illegible] Lias, two of them from England and one from Germany.

Aporoblattina Eatoni sp. .

Pl. 48, fig. 19.

This specimen is a nearly complete wing of the same color as the light, dirty brown stone on which it is preserved, with very dark brown veins; it is perfectly flat, but the veins are slightly impressed in places; it has the appearance of being the upper surface of a hind wing, partly folded in the partially incomplete anal region. The costal margin is perfectly straight in the basal half, then more and more arcuate, meeting at a broad angle the arcuate curve of the lower part of the wing at the scarcely angulate apex in the middle of the upper half of the wing. The basal half of the costal area appears to be narrowly folded. The mediastinal vein is straight, terminating in the middle of the outer half of the wing, with a few distant, longitudinally oblique, but short, simple branches. The scapular vein is also straight, terminates just below the tip and is furnished with three or four longitudinal, slightly upcurved branches, compound apically, and originating at equal distances far apart, the second in the middle of the wing. The externomedian vein is also straight, first divides in the middle of the wing and is very slightly and longitudinally branched. The internomedian vein, also straight, but slightly declivous to beyond the middle of the wing, then bends slightly downward, and has four slightly arcuate, longitudinally oblique, equidistant and rather distant simple branches. The anal vein has branches similar to the preceding, but, apparently by a fold, they are made to take a more longitudinal course.

Length of wing, 15 mm.; breadth, 6.5 mm. It comes from the English Purbecks, was sent me by Rev. Mr. Brodie, and is named for Rev. A. E. Eaton who has contributed slightly to our knowledge of fossil insects.

Aporoblattina anceps.

[Without name] Westw., Quart. Journ. Geol. Soc. Lond., x, 396, Pl. 15, fig. 22.
Blattina anceps Gieb., Ins. Vorw., 317 (Giebel wrongly quotes fig. 21).

This small species seems to be closely allied to *A. Eatoni*, but of a very different shape, the costal margin being quite as arcuate as the lower margin, or more so, and the bluntly rounded apex being in the middle of the wing. The characteristics of the neuration are in general similar to those of *A. Eatoni*, but the externomedian vein (which is probably wrongly represented as attached at base of fragment to the scapular vein) is only once forked, near the tip, and the branching of the scapular vein is much simpler.

Length of fragment, 7 mm.; probably the wing is not much longer; breadth, 4 mm. Lower Purbecks, Durdlestone Bay.

Aporoblattina McLachlani sp. nov.

Pl. 48, fig. 18.

[Without name] Westw., Quart. Journ. Geol. Soc. Lond., x, 396, Pl. 18, fig. 35.

Westwood looked upon this wing as neuropterous, and apparently as more complete than it seems to be, its true dimensions being attempted to be shown in the figure here given, which is taken, with scarcely any doubt, from the same specimen, now in the collection of Rev. P. B. Brodie. The specimen is slightly duskier than the dirty, chalky-white stone, perfectly flat, with delicately impressed veins which are the clearer for being filled with dirt. Next the anal area another wing partly overlies this, but it is not drawn. The wing was of a sub-oval form with a very much fuller curve below than above, the apex, which is rounded though produced, being in the middle of the upper half of the wing. Only the tip of the mediastinal vein appears on the fragment, and it is very similar to that of *A. Eatoni*, terminating probably a little before the middle of the outer half of the wing. The scapular vein differs from that of *A. Eatoni* considerably, terminating scarcely above the apex and having only simple oblique branches in the outer third of the wing, and a single longitudinal also simple branch, arising one-third the way from the base. The internomedian vein is much as in *A. Eatoni*, but only branches in the apical third of the wing. The externomedian vein occupies an even broader field than in the last species, with similar but more arcuate, and apically more longitudinal branches, also simple. The anal veins are not seen.

Length of fragment, 6.75 mm.; probable length of wing, 8.5 mm.; breadth, 4.75 mm. From the English Purbecks, named for Mr. R. McLachlan, whose well-known entomological studies have extended occasionally to fossil insects.

Aporoblattina Westwoodi sp. nov.

[Without name] Westw., Quart. Journ. Geol. Soc. Lond., x, 396, Pl. 18, fig. 28.

Westwood looked on this wing as phryganideous, but it plainly belongs in this immediate vicinity, resembling closely the preceding species, from which it differs in its greater size and slenderness, in the forking of the first branch of the scapular vein (no branch in any part of the wing is forked in *A. McLachlani*) and in the generally less regular disposition of the branches of the scapular area. The externomedian vein is also simpler and less regular.

The fragment is 10.5 mm. long and 5 mm. broad. Probably the wing reached a length of 11 mm. It comes from the lower Purbecks of Durdlestone Bay.

Aporoblattina Kollari.

[Without name] Brodie, Foss. Ins. Engl., 33, 119, Pl. 5, fig. 14.
Blatta Kollari Gieb., Ins. Vorw., 322.

Westwood, in Brodie's work, looked upon this as belonging to a family of Neuroptera "of which Corydalis is the type." It plainly belongs here, and is apparently not distantly allied to the two preceding species and especially to *A. Westwoodi*, from which it is distinguished by its still slenderer form, and the greater straightness and regularity of its scapular branches.

Length, 18 mm.; breadth, 6.5 mm. It comes from the Purbeck strata of the Vale of W[illegible]

Aporoblattina incompleta.

[Without name], Brodie, Foss. Ins. Engl., Pl. 8, fig. 13.
Blattina incompleta Giebel, Ins. Vorw., 317.

This species differs somewhat from the preceding forms and is very imperfect, but seems to belong here, and to be not distantly related to *A. Westwoodi*, but with the externomedian area much more fully developed, with nervules simulating those of the scapular area. Both scapular and anal areas are wanting.

Length of fragment, 8.5 mm.; width of same, 3.75 mm.; probable length of wing, 11 mm.; probable breadth, 4.25 mm. It comes from the English Lias.

Aporoblattina recta.

[Without name], Brodie, Foss. Ins. Engl., 33, 119, Pl. 5, fig. 3.
Blattina recta Gieb., Ins. Vorw., 318.

This also Westwood looked upon as allied to Corydalis, but it is clearly related to the others. It is a small and slender species, but, excepting for the changes in neuration which this involves, closely resembles *A. McLachlani*. The externomedian branches only near the tip and entirely beyond the extremity of the mediastinal area, occupying the tip with its forked branches, which, in contradistinction to all the other veins are both superior and inferior; all the other branches are simple.

Length of fragment, 6.5 mm.; probable length of wing, 8 mm.; breadth, 2.75 mm. It comes from the Wealden of the Vale of Wardour.

Aporoblattina nana.

Blattina nana E. Gein., Flötzform. Mecklenb., 30, Pl. 6, fig. 2.

This minute species appears to belong here, though it differs conspicuously in the more longitudinal and straighter branches, most noticeable in the internomedian area. It is a little difficult to tell where the separation of the scapular and externomedian veins should be placed, as the base is broken, but it would appear probable that Geinitz's construction of the neuration is correct, in which case the very small development of the scapular is a marked feature of the species.

Length of fragment, 5 mm.; probable length of wing, 6.5 mm.; breadth, 2.4 mm. It comes from the Lias of Dobbertin, Germany.

Aporoblattina exigua sp. nov.

[Without name], Westwood, Quart. Journ. Geol. Soc. Lond., x, 390, 396, Pl. 18, fig. 38.

This species, represented by a wing which Westwood regarded as orthopterous, seems to belong here and to be nearly related to *A. nana*, than which it is not much larger. The mediastinal vein runs to the middle of the outer half of the wing. The scapular vein runs almost straight to the tip, and, commencing to branch pretty near the base, sends four widely and equally distant, superior, and almost longitudinal branches to the margin, which in the outer third of the wing are considerably forked, so that the tip is crowded with terminal branches. The externomedian is similarly branched, but narrowly and only quite beyond the middle of the wing. Even the unusually longitudinal branches of the here comparatively narrow externomedian area are forked in the apical third of the wing. The anal area appears to be brief and narrow with two or three oblique veins. The narrowness of the wing is its marked feature, disguising its resemblance to its allies, next to which is the general multiplication of branches in the apical third of the wing. It is from two and a half to three times as long as broad.

Length of fragment, which is very nearly complete, 9 mm.; breadth, 3.6 mm. It comes from the lower Purbecks of Durdlestone Bay. Heer referred it to Blattidium.

Aporoblattina Butleri sp. nov.

Pl. 48, fig. 15.

A single specimen and its reverse on a grayish-brown stone, in which the surface, perfectly flat, is of the same color, excepting for the reddish-brown veins slightly impressed on one, slightly prominent on the other, represent this species. It is but a fragment, and is the only one placed here which appears to have certainly no externomedian vein; a mere fragment of the costal margin remains, but a conjectural outline is given on the plate, hardly consonant with the idea that it is a hind wing; indeed the presence and character of the anal vein (which is, however, no more depressed than the others) hardly allows that supposition, so that it is probable that it does not belong in this group. Still the neuration strongly reminds one of that of these species, with the single exception of the arcuate anal furrow, and the absence of the externomedian vein. The mediastinal vein extends beyond the limits of the fragment, but undoubtedly stops considerably short of the tip (running at first parallel to (?) and afterwards) approaching the not distant costal margin, with few, distant, longitudinally oblique, nearly straight and simple branches. The scapular vein runs, apparently to the tip of the wing, in a nearly straight course far from the costal margin, yet commences to fork only just before the middle of the wing and has only two or three superior, longitudinal, so far as can be seen simple, distant branches. The median vein runs in a nearly straight course, parallel to the former, [illegible] the middle of the wing, and has only a few similarly distant, longitudinally arcuate, so far as can be seen simple veins, all, or all but one of which, arise near together [illegible] the middle of the wing. The anal furrow is broadly arcuate, terminating probably [illegible]fore the middle of the wing.

Length of fragment, 8.25 mm.; probable length of wing, 12 mm.; its breadth, 4.25 mm. [illegible] the English Lias and was sent by Rev. Mr. Brodie for examination. It [illegible] Mr. A. G. Butler, of the British Museum, who has contributed somewhat [illegible]ge of English fossil insects.

APPENDIX.

There are a few species, imperfectly preserved, concerning which we can come to no satisfactory conclusions. Such is *Rithma ramificata* Giebel (figured by Westw., Quart. Journ. Geol. Soc. Lond., x, Pl. 15, fig. 20), in which all the veins, or at any rate all but one are represented as originating from a single root. It is perhaps an Elisama.

Another is *Blattina incerta* Geinitz (Zeitschr. deutsch. geol. Gesellsch., 1884, 571, Pl. 13, fig. 2), which the author compares to *Ctenoblattina Langfeldti*, a resemblance which would not have been mentioned if a mistake had not been made in the interpretation of the margins of the wing of the latter species, as mentioned above. By the distance of the mediastinal vein from the margin, it would appear to be a front wing: but for that and for the corresponding very strongly arcuate front margin, it would appear to be a hind wing, and to be not far removed from the wings I have placed in Aporoblattina. As, however, it is clearly a front wing, as all the veins appear to be independent, and as its general form and the general distribution of the areas are very different from that of mesozoic cockroaches in general, I am strongly inclined to doubt the Blattidean relationship claimed for it, and to look at it rather as a neuropterous wing allied to Hagla.

There is also the mere fragment of a wing figured by Westwood (Quart. Journ. Geol. Soc. Lond., x, Pl. 15, fig. 19) which is probably less than a quarter of the whole wing, and the apical portion at that, which is probably quite indeterminate. Heer refers it to Blattidium.

The fragment of a wing figured by Brodie (Foss. Ins. Engl., Pl. 5, fig. 6, *cf.* p. 121) from the Wealden is apparently the anal area of a cockroach, in which the upper curve represents the anal furrow and the lower, with the veins falling on it, the inner margin of that part of the wing. It seems to have belonged to a species about the size of *Rithma Westwoodi.*

The insect from Solenhofen (Jura), which Heyden (Palaeontogr., I, 100-101, Pl. 12, fig. 5) figures under the name of *Blabera avita*, but which he says "einer eigenen Gattung angehören mag," on account of the shape of the tegmina, has rather on his plate the appearance of a Cybister or an Hydrophilus, but until further examination of the original or of other specimens, cannot be definitely fixed. There is nothing, either in shape or neuration (which appears to be very obscure), which shows any relation to other mesozoic forms, and with the exception of the Solenhofen species of the abnormal and widely different genus Pterinoblattina, it is very much larger than any other mesozoic forms of this family.

Finally a species from the Jura of Solenhofen is mentioned and rudely figured by Weyenbergh (Periód. Zool., I, 86, Pl. 3, fig. 12) under the name of *Blattaria Dunckeri*; but all he says of it is that it is characterized by the abdominal appendages and the small head. As far as the figure goes, there seems to be nothing to show that it is certainly a cockroach, still less where it belongs; no wings are preserved.

EXPLANATION OF PLATES.

PLATE 46.

Fig. 1. [illegible] *[illegible]acta.* Drawn by Katherine Peirson. Purbecks, England.
" 2. " " Drawn by J. Henry Blake.
" 3. *Mes[illegible]*, sp. ¼ Drawn by Miss Peirson. Purbecks, England.
" 4. *Rithma Stricklandi.* ⁴⁄₁ Showing only the left upper wing, drawn by Mr. Blake. Purbecks, England.
" 5. " " ⁴⁄₁ The entire insect. Drawn by the same.
" 6. *Rithma Westwoodi?* ¼ Drawn by Miss Peirson. Purbecks, England.
" 7. *Rithma liasina.* ⁴⁄₁ Drawn by the same. Lias. Strensham.
" 8. *Rithma*, sp. ⁴⁄₁ By the same. Purbecks, England.
" 9. *Mesoblattina Geikiei.* ¼ By the same. Lias, Brown's Wood, Warwickshire.
" 10. *Mesoblattina Swintoni.* ⁴⁄₁ By the same. Purbecks, England.
" 11. *Rithma Westwoodi.* ⁴⁄₁ By the same. Purbecks, England.
" 12. *Mesoblattina Blakei.* ¼ By the same. Upper Lias, Alderton.
" 13. *Mesoblattina*, sp. ⁴⁄₁ By the same. England.
" 14. *Rithma disjuncta.* ⁴⁄₁ By the same. Purbecks, Wiltshire.
" 15. *Rithma Gossii.* ⁴⁄₁ By the same. Purbecks, England.
" 16. *Rithma Daltoni.* ⁴⁄₁ By the same. Purbecks, England.
" 17. *Mesoblattina Bensoni.* ¼ By the same. Upper Lias, Dumbleton.

PLATE 47.

Fig. 1. *Elisama Kneri.* ⁴⁄₁ Drawn by Katherine Peirson. Purbecks, Wiltshire.
" 2. *Mesoblattina Bucklandi.* ¼ By the same. England.
" 3. *Elisama Kirkbyi.* ¼ By the same. England.
" 4. *Mesoblattina Murrayi.* ¼ By the same. Purbecks, England.
" 5. *Mesoblattina Murchisoni.* ¼ By the same. Purbecks, England.
" 6. *Mesoblattina*, sp. ¼ By the same. Purbecks, England.
" 7. *Mesoblattina Brodiei.* ¼ By the same. Purbecks, England.
" 8. *Elisama Bucktoni.* ¼ By the same. Purbecks, England.
" 9. *Mesoblattina Mantelli.* ¼ By the same. Purbecks, England.
" 10. *Mesoblattina Peachii.* ¼ By the same. Purbecks, England.
" 11. *Mesoblattina Hopei.* ¼ By the same. Purbecks, England.
" 12. *Elisama Bucktoni.* ¼ By the same. Purbecks, England.
" 13. *Elisama minor.* ⁴⁄₁ By the same. Purbecks, England.
" 14. *Mesoblattina Higginsii.* ¼ By the same. Purbecks, England.

PLATE 48.

Fig. 1. *[illegible] Wallacei.* ⁴⁄₁ Drawn by Katherine Peirson. Purbecks, England.
" 2. *[illegible]* Drawn by J. H. Blake. Purbecks, Dorset (see fig. 8*a*).
" 3. *[illegible] Prestwichii.* ⁴⁄₁ Drawn by Miss Peirson. England.
" 4. Part of the upper wing of an Orthopteron ("Grasshopper," Westwood.) ¼ Drawn by Mr. Blake. Purbecks, Dorset (see fig. 8*b*).
" 5. *[illegible] Butleri.* ⁴⁄₁ Drawn by Miss Peirson. Purbecks, England.
" 6. *[illegible] Woodwardi.* ¼ Drawn by Mr. Blake. Purbecks, Wiltshire.
" 7. *[illegible]* ¼ Drawn by Mr. Blake. Purbecks, Wiltshire (see fig. 8*c*).
" 8. [illegible] stone from Purbecks of Wiltshire, showing in their natural size the species represented in figures 2, 3, 7, 10, 11, 12, 13. Compare the figures by Westwood in Quart. Journ. Geol. Soc. Lond., x, Pl. 15, 1, 2, 4. Drawn by Mr. Blake.
" 9. *[illegible]* ⁴⁄₁ Drawn by Miss Peirson. Upper Lias. Alderton.
" 10. [illegible] wing, according to Westwood. ¼ Drawn by Mr. Blake. Purbecks, Wiltshire (see fig. 8*f*).
" 11. [illegible] Drawn by Mr. Blake. Purbecks, Wiltshire (see fig. 8*g*).
" 12. [illegible] wing, according to Westwood. ¼ Drawn by Mr. Blake. Purbecks, Wiltshire, (see fig. 8*d*).
[illegible], Westw. ⁴⁄₁ Drawn by Mr. Blake. Purbecks, Wiltshire (see fig. 8*e*).
[illegible] Drawn by Miss Peirson. Purbecks, England.
[illegible] Drawn by Miss Peirson. Lias. England.
[illegible] Drawn by S. F. Denton. Upper Lias, Alderton.
[illegible] A composite figures from the obverse and reverse together. Drawn by Mr. Blake.
[illegible]
[illegible] Drawn by Miss Peirson. Purbecks, England.
[illegible] Drawn by Miss Peirson. Purbecks, England.

INDEX OF SPECIES.

XVIII. A NORTH AMERICAN ANTHURUS—ITS STRUCTURE AND DEVELOPMENT

By Edward A. Burt.

Last September, toward the close of a prolonged rain, the writer had the good fortune to find a member of this fine genus of the Phalloideæ. The plant was growing in a sandy cornfield on a hillside near East Galway, New York. Gathering from the literature at hand that some genera of this family have not been satisfactorily investigated on account of the difficulty of obtaining sufficient material well preserved for study, a careful search was made which yielded thirteen mature individuals and several "eggs" in various stages of growth. This ample supply of material was preserved in alcohol and has remained in very favorable condition for determining the structural features and the development of the species.

Gross Structure.

The general aspect of a rather old specimen of the fungus, which will be referred to throughout this article under the name of *Anthurus borealis*, sp. nov. (see diagnosis at the close), is shown natural size in Fig. 1. A slender clavate stipe issues from a volva, the torn apex of which is just at the surface of the ground. Both volva and stipe are white, and the latter has a pitted surface. The stipe is somewhat contracted above and then divides into six erect and narrowly lanceolate arms which bend in together at their tips. Six seems to be the normal number of these arms, but in some instances the sixth is only partially developed. The full height of the plant is from 10 to 12 cm.; the length of the arms 1 1-2 to 2 cm.; the diameter of the stipe is about 1 cm. below and 1 1-2 cm. at the broadest part above.

The back of each arm is pale flesh-colored and has a small median furrow extending its entire length. Toward the upper end of the arm the furrow is broader and very shallow, lower down it becomes narrow and correspondingly deeper, and at the base of the arm it widens abruptly, becomes very shallow, and disappears on the surface of the stipe. The lateral and inner faces of the arms are covered by the brownish olive-green gleba (Fig. 2) until the plant reaches its maturity. Then deliquescence of the gleba occurs — accompanied by a fetid odor which is, however, perceptible for a distance of only a few feet — and the arms, upon becoming bared from their covering of spores, expose a surface marked by irregularly branching transverse wrinkles, which do not cross the backs of the arms (Fig. 1).

Upon splitting the mature fungus longitudinally, the stipe is found to be thick-walled and with a large central cavity. The surface of this cavity is cross wrinkled (Fig. 4). A longitudinal radial section of the wall (Fig. 4) shows a cavernous structure of about three series of cavities running longitudinally and almost separated from each other, and cut up by plates and folds of the pseudoparenchymatous tissue of the wall.

Near the plane of union of the stipe with the arms a thin diaphragm, having an aperture of variable size and position, but often central, separates the main central cavity of the stipe from a dome-shaped cavity above (Fig. 4). The dome-shaped cavity is closed above, and differs from the central cavity of the stipe in having a wall with an even inner surface. Thin sheets of white tissue pass out laterally from the wall of the dome into the spaces between neighboring arms and extend vertically upward through the gleba. The plane of section for Fig. 4 is a nearly median one between neighboring arms, and cuts these sheets longitudinally in areas marked *T*, Fig. 4. The gleba is here marked *g*. The hymenial surface is borne upon a very complicated system of folds and pockets, or closed chambers, of this tissue (*h*, Fig. 20), as will be described further on.

The spores (Fig. 12) are apparently olive-green, simple, ellipsoidal, 3-4 $\mu \times$ 1 1-2 μ. They are borne in clusters of from 5 to 8 at the ends of slender basidia which are divided into 4 or 5 short cells and are constricted at the septa (Fig. 11). But this is to be considered again further on.

A median longitudinal section through the arm and the dome (Fig. 5) shows that the inner face of the arm is adnate to the dome for about one sixth of the length of the arm. This results in confining the gleba in this lower portion of the arm to the spaces between the lateral faces of the arms (Fig. 8). There exists here in the lower portion of each arm the condition which Patouillard[1] has shown to exist in *Lysurus mokusin* (Cibot) Fr. throughout the entire length of the arm.

Each arm is hollow (Fig. 5). Its outer and inner surfaces are approximately parallel, the wall being really thrown into transverse folds rather than merely wrinkled in its structure, as seems to be the case when viewed externally after the deliquescence of the gleba.

[1] Patouillard, Fragments mycologiques X. Organisation du *Lysurus mokusin* Fr., p. 65-70. And also Journal de Botanique, 1890, p. 252.

At the sides of the dome and near the diaphragm, two smaller cavities may be seen (Fig. 4). Passages are shown leading out from each of these. The passage *k* near the diaphragm leads into a similar small cavity in the next space between two arms. By a series of six such small cavities and connecting passages a complete circuit is made through the wall of the stipe at its upper end. Each of the small cavities is in communication with the large cavity of each of the two adjacent arms above by passages marked *l*. Irregularly shaped small cavities extend from the ring-like system just described down into the wall of the stipe. This system of cavities does not show in this region any direct connection with the cavity of the dome or with the main central cavity of the stipe.

The course of these cavities from the chambers in the wall of the stipe up into the arms is of special interest as showing the arrangement and distribution in early stages of the bundles of hyphae which then filled these cavities. But this subject will come up again in tracing the development of the plant.

The so-called "eggs" are found underground either singly or in clusters of from two to four upon branching mycelial strands (Fig. 3). In the fresh condition they vary in form from nearly spherical to oval, but upon lying in alcohol they contract more in transverse than in longitudinal diameter. An "egg" just beginning to rupture at the apex had a diameter of 2 cm. The wall of the peridium has the usual structure of three layers, of which the outer and the inner are thin white membranes, but composed of very different hyphae however. These layers are separated by a broad layer of gelatinous tissue (M′, Figs. 7–9).

Histology and Development.

The Mycelial Strand.

Full-grown mycelial strands upon which the "eggs" are borne may have a diameter of 2 mm. These strands show a broad medullary layer of fine hyphae running longitudinally and a narrow cortical layer consisting of hyphae more irregular in their form and course, more interwoven, and with occasional short lateral branches extending outward to the surface of the strand. There is no sharp separation of these layers—the medullary layer passes gradually into the cortical.

Crystals of calcium oxalate have been found in the cortical portions of some members of the Phalloideae, as by De Bary[1] in *Phallus caninus* and by Fischer[2] in *Clathrus can-*

[1] De Bary: Beitr. z. morph. u. physiol. der pilze. Zur morph. der phalloideen, p. 59.

[2] Ed. Fischer: Untersuch. z. entwick. der phalloideen, p. 3.

[illegible]*tas*. Such crystals occur in the cortical portions of *Clathrus columnatus* Bosc., specimens of which, collected in Florida, I have been enabled to examine through the kindness of Professor Farlow. The Anthurus shows no crystals.

The Youngest Egg Found.

The youngest egg of the Anthurus material, after lying in alcohol, was elliptical in median longitudinal section, being about 6 mm. long by 3 mm. wide. After staining with carmine and imbedding in paraffin, one half was cut into longitudinal sections and the other into transverse sections.

In this stage of the egg the two tissues of the mycelial strand can still be made out, but they are undergoing such differentiations as already to show recognizable early conditions of most parts of the mature plant. The stipe is here a slender body extending from the mycelial strand to the central part of the egg (Fig. 14). This central portion consists of the gleba *g* and fundament of the arms *a′*. Surrounding these structures is a broad layer M′ somewhat horseshoe-shaped in the section and constituting the principal mass of the egg. This becomes the gelatinous layer of the peridium.

The structure of this egg in detail is as follows:—

The medullary tissue of the mycelial strand is prolonged up through the stipe in a bundle of slender longitudinally running hyphae, marked M. This bundle is, for the most part, separated from the fundament of the wall *a* by a slight space, but at some points single hyphae and small bundles run obliquely upward across the space and up along the wall (Fig. 15). Near the lower end of the stipe medullary hyphae pass into the wall.

Toward the central part of the egg the hyphae of the bundle M spread out in a sheaf-like manner and form an early stage of the gleba and its supporting structure. At *n*, Figs. 14 and 16, the medullary hyphae from the gleba may be seen running out directly into the broad layer M′, which has been mentioned as becoming the gelatinous layer of the peridium.

The layer M′ is already somewhat set off from the tissue of the gleba by very fine hyphae which stain more deeply with the carmine than does the surrounding tissue, and which lie in a very thin and open layer covering the future gleba and arms, or pass perpendicularly through the masses of hyphae *n* connecting the gelatinous layer M′ with the gleba tissue. This thin layer of rather scattered hyphae is the beginning of the inner wall of the peridium (*i*, Figs. 15–16). Under higher magnification (Fig. 17), this layer may be seen to receive some of its hyphae from gleba tissue, where they seem to have a subhymenial position.

Of the tissues already considered, the bundle forming the axis of the stipe, the gleba, and the gelatinous layer of the peridium, are direct continuations of the medullary tissue of the mycelial strand and must be regarded as of medullary origin. The inner wall of the peridium has the same origin probably on account of its subhymenial connections.

The cortical tissue of the mycelial strand is continued in the thin outer layer of the egg (C, Figs. 14 and 16). The hyphae of this layer have become more irregular in form, and branch and change their course so as to become extremely interwoven. The tissue remains loose, and must allow circulation of air throughout its whole extent. By referring to the cross section (Fig. 16), portions C′ of the cortical tissue may be seen extending inward from the main peripheral mass of this tissue to the gleba. There are six of these portions placed at about equal distances apart in the cross section. They have the position of walls or plates extending from the base of the egg longitudinally upward to a short distance above the gleba mass, and extending inward from the peripheral layer to the fundament of the stipe and arms. In all of the lower and middle portions of the egg, these plates of cortical tissue divide the gelatinous layer M′ into six parts, the hyphae of which do not cross through the partition from any part into the adjacent one. The partitions do not extend to the apex of the egg — at least not in this nor in the more advanced stages which I have examined. Above the level of the upper ends of the arms, the portions extend inward from the cortex only a part of the distance to the axis, and the amount of this inward extent diminishes rapidly higher up, so that near the apex of the egg the partitions become so shallow as to be hardly more than traces along the inner face of the cortical layer. It follows from this that in the upper part of the egg, there is but a single mass of the gelatinous layer M′ and that this is divided below by the cortical partitions into the six masses already mentioned.

In the lower third of the egg, there is a cylindrical layer of tissue (C″, Figs. 14 and 15) similar to that of the partitions and into which they pass. This layer completely surrounds the fundament of the stipe and wholly separates it from the gelatinous layer of the peridium. Toward the inner face of the layer C″, its hyphae anastomose less frequently and are less branched, but become closely and irregularly laterally inflated. In preparations stained with paracarmine alone, the walls of these hyphae were but slightly stained as compared with their protoplasmic contents. In such preparations the greater masses of protoplasm at the inflated portions gave to the hyphae a dotted look under low and medium magnification (*p*, Figs. 14 and 15). In the double-stained preparations with the cell-walls well brought out, these hyphae appeared under high magnification as shown in *x* and *x*′, Fig. 18.

The inflated hyphae do not wholly compose the fundament of the wall of the stipe; small bundles of fine hyphae *b* are also present but cannot be traced long distances. These uninflated hyphae are undoubtedly of medullary origin, as they closely resemble the medullary hyphae of the main cavity of the stipe, and, as stated in a former place, similar bundles of hyphae pass from the medullary portion into the wall of the stipe near its base. The inflated hyphae seem to occupy the spaces between the bundles of uninflated medullary hyphae in the fundament of the stipe.

The stipe seems to be composed in part of tissue of medullary origin, and in part of tissue of cortical origin. Later stages of the egg show that the medullary tissue of the wall becomes the gelatinous tissue of the chambers and finally disappears, while the inflated hyphae of cortical origin differentiate further into pseudoparenchyma.

The arms of the receptaculum are borne upon the upper end of the wall of the stipe. In this stage of their development, they consist of six large masses of longitudinally running hyphae (*a*, Figs. 14–17) passing upward from the fundament of the wall. In the lower part of each mass, the tissue is very dense and seems to consist of both the medullary and cortical tissues of the stipe wall but with the medullary hyphae collecting into the centre of the mass. Further up the hyphae of the mass seem to be wholly of medullary nature. Each of these masses is the fundament of an arm and lies in a V-shaped cavity extending upward along the surface of the gleba (Figs. 14–17). The arm is in contact with the supporting tissue of the gleba near the lower end—at about the region of the future dome; but I cannot detect any hyphae passing from the one structure into the other here.

The arms arise at the inner edges of the cortical plates (Figs. 16–17). Hyphae from these plates cross the narrow separating space and come into contact with the fundament of arms. I am inclined to think that these hyphae merely reach the fundament and do not enter it, and that we have here, for this part of the arm, the first penetration of the cortical tissue into and across the narrow surrounding space which this tissue takes full possession of later on and in which it builds up the wall of the arm.

The surface of the cavities in which the arms lie is lined by a palisade-like layer of cells closely packed together, which stain deeply with the carmine. They are the swollen ends of branches given off by the spreading hyphae of the medullary system. This layer of cells is the young hymenium (*h*, Figs. 14–17), and the swollen cells are the young basidia. This hymenial layer is thrown into a series of folds which, judging from cross sections, extend principally in a longitudinal direction and have their hollows directed somewhat centripetally in between the radiately spreading hyphae of the gleba

(Figs. 16 and 17). In some places these folds have their surface thrown into a secondary series. Here the small depressions of these folds extend into the primary fold in the direction that the hyphal branches must have originally taken in passing toward the surface of the cavity from the deeper tramal tissue of that primary fold. The impression gained from the branched structure of the chambers is that originally simple chambers have had branches form in the tissue of the gleba through the gradual spreading apart of the masses of hyphae which reached to the surface of the first chambers, and that this spreading apart followed from the need of a greater surface consequent upon the abundant production of basidia in the region of the existing chambers. That the formation of the basidia causes the formation of branches of the chambers, seems to be shown by the fact that the most remote portions of the branch-chambers are constantly lined with the basidia. That the basidia form only in the region of already existing chambers seems to be shown by the fact, that upon running through the series of cross sections, small chambers are not found absolutely isolated from the large chambers. They may seem so isolated in some sections, but others show the connection.

How has there arisen from the simple conditions of the cortical and medullary tissues in the mycelial strand the more complicated and yet symmetrical disposition of these tissues in the egg just described? How have the six masses of the gelatinous layer of the peridium come to be separated from each other by plates of cortical tissue? How happens it that these masses of gelatinous tissue are connected with the medullary tissue from which they originate, only in the upper part of the egg? Was there a connection down to the base in a younger stage?

Determination of Earlier Development by Reference to Clathrus.

No younger egg of Anthurus is available for a direct answer to these questions, yet the stage of development just described bears in certain features so much in common with the better known genus Clathrus that approximately correct answers may nevertheless be had.

The earlier conditions of *Clathrus cancellatus* have been examined and illustrated by Fischer.[1] His earliest stage (Taf. 1, fig. 1) shows the medullary tissue of the mycelial strand spreading out in the pyriform egg and sending several radiating branch-like masses into the cortical region. Broad masses of cortical tissue occupy the spaces between these branches. In a slightly older stage the medullary branches have by growth become much broader in their peripheral portion and have crowded the separating

[1] Ed. Fischer: Untersuch. z. entwick. der phalloideen, p. 3, taf. 1 und 2, fig. 1–7.

cortical portions into narrow plates. These stages bring the development up to the conditions shown in Fischer's Figs. 3 and 4, which are quite similar to my Fig. 16 except perhaps in the case of the fundament of the arm.

These early stages of *C. cancellatus* rather indicate that the arrangement in the peridium of masses of gelatinous tissue separated from each other by plates of cortical tissue has resulted from the extrusion into the early cortical layer of masses of more vigorously growing medullary tissue; still such stages do not forbid the interpretation that the cortical tissue has taken the initiative and has intruded into the medullary region forming the plates.

The supply of *Clathrus columnatus* Bosc., to which reference has been made on a preceding page, contained one egg in an earlier stage than those of *C. cancellatus* described by Fischer. *Clathrus columnatus* in its mature form is characterized by a receptaculum having usually four meridionally ascending arms which are joined together into two opposite pairs above, and then these pairs are joined together by a single connecting portion. The youngest egg of this species, as taken from the alcohol, was pyriform in general form (Fig. 19) and somewhat flattened on two opposite sides, so that a cross section would be elliptical rather than circular. Four well-marked ridges run meridionally and are separated from each other by furrows. Upon sectioning this egg it was found that these ridges are wings of the medullary tissue. The cortical tissue of the furrows is especially loose, and hyphae from two opposite sides seem to be bridging and filling in the furrows. But the important feature is, that the outer surface of the cortical layer conforms to the ridged medullary surface to a much greater degree than in later stages, thus indicating that the medullary layer has taken the initiative in the disposition of the tissues of the egg.

The question in regard to the arrangement in *C. columnatus* of the gelatinous layer of the peridium in four masses—as in most cases—separated from each other throughout by four plates of cortical tissue, may be answered by stating that it has resulted from the extrusion of the medullary tissue along four longitudinal lines out into the cortical region. Here the entering masses have broadened out in their peripheral portions so as to crowd the cortical portions between the masses into narrow plates. The answer to this question for *Anthurus borealis* is somewhat the same, but is complicated by the generic differences between Clathrus and Anthurus. In *C. columnatus* the cortical plates extend from the base to the apex of the sporophore, cutting off all direct connection of each gelatinous mass with its neighbors. This indicates that the medullary extrusions were strictly lateral. In *A. borealis*, it has been pointed out that the six cortical plates do not extend to the apex of the sporophore, and that the six gelatinous masses are in direct connection with each other above and also have radial connection with the medullary tissue of the gleba along six lines (*n*, Fig. 16). Such connections indicate not only that in this species medullary extrusions have occurred laterally along six longitudinal lines in the region of the arms, as in the Clathrus, but that such extrusion upward and outward has also occurred from the upper end of the medullary column.

With regard to the last question, as to whether in an earlier stage the gelatinous masses of the peridium were connected down to the base with the column of medullary tissue in the main central cavity of the stipe, I think that an answer in the negative may be safely ventured. *C. columnatus* has such connections, and they determine the mature form of the fungus. Were such connections originally present in *A. borealis*, some slight indications of the fact, as by the directions of the hyphae, or by some slight persisting connection, as by breaks in the uniformity of structure of the fundament of the wall of the stipe, would have been found in some of the sections. After passing into the cortical region, the medullary masses must have crowded their way downward into the cortical tissue by the means that in *C. cancellatus* has compressed the broad masses of cortical tissue shown in Fischer's Fig. 1, of his work already referred to, into the compact plates of his Fig. 2. That the medullary tissue which becomes the gelatinous layer of the volva may crowd its way down into a loose pre-existing tissue was shown by De Bary in his careful observations upon the egg of *Phallus caninus*.[1] But it is quite probable that the greater portion of the length of the gelatinous masses below the level of the arm is to be accounted for by the fact that the arms were at a much lower level when extrusion of the masses occurred, and that while they have retained their connection with the gleba, they have also grown and lengthened with the growth of the stipe and the egg in general.

Development of Anthurus in Next Older Egg.

Let us now pass to the later development of Anthurus. A more advanced stage than that already considered is shown in Fig. 20. This represents in cross section one of the arms, the surrounding gleba, and the cortical plate passing from the arm through the gelatinous layer of the volva to the cortex. The location of the figured portion in the entire cross section may be seen by reference to Fig. 7, although this latter is from a still more advanced stage of the egg.

In Fig. 20, one is struck by the great development of the gleba, as compared with that in Fig. 17. Still the repeated formation of new series of folds upon the surface of those already existing would ultimately give a very intricate structure. Indications of such a method of folding were afforded by the younger stage. The great number of small closed chambers shown in this section and in those of later stages seems to show that

[1] De Bary: Beitr. z. morph. u. physiol. der pilze. 1. Reihe. p. 194. taf. 29. fig. 3 und 4.

some other factor than repeated folding has aided in their formation. The cavities between the primary and secondary folds of Fig. 17 can now be followed only with great difficulty, and in these cases they seem to be rows of small closed chambers with occasional connecting passages. These systems of cavities are also frequently cut off from reaching quite up to the wall of the arm, which is now developing in the narrow space about the fundament of the arm of the younger stage. All of the chambers in that stage opened into this space.

The breaking up of the earlier communicating chambers into the many small chambers of this section, seems to indicate that at those places in which changes occurring in the gleba have caused folds to be crowded into close contact, hyphae from the tramal tissue of the one fold, or of each fold, pass into the other and bring about an anastomosis of the folds. Indications of such anastomoses in formation are not infrequent. In his study of *Ithyphallus tenuis* Fischer[1] pointed out that it may be that anastomosis of neighboring folds is a factor in the formation of the closed chambers of the gleba.

The deeply staining cells of the hymenial layer are now more elongated and are basidia, bearing a cluster of spores at their outer ends. These basidia already show the series of constrictions which become so singular a feature in later stages.

Great development of the arm has been taking place. It now fills the whole of the cavity which in Fig. 17 was only partially occupied by its fundament, and is in close contact with the folds of the gleba. Two quite distinct tissues now compose the arm. There is a central mass of fine hyphae running mostly in a longitudinal direction. This tissue is highly gelatinous and, in the double-stained preparations, takes the same orange color that is taken by the gelatinous layer of the peridium, by the tramal tissue, and by the central tissue of the stipe,—all of which are of medullary origin.

The second tissue of the arm surrounds the gelatinous constituent. It consists of a narrow layer of hyphae connected with the tissue of the cortical plate. These hyphae are branched and irregularly inflated, and are developing into the pseudoparenchyma. This tissue retains in the double-stained preparations the purplish red color given by the carmine, and is sharply distinct from the gelatinous tissue of the arm on the one side and from the gleba on the other. It seems to find conditions for its development most favorable along the surfaces of contact with the gelatinous tissue of the arm and with the gleba rather than midway between these two surfaces. This causes a rather more compact arrangement of this tissue next to these surfaces than in the middle of the space between them. This appearance has been referred to repeatedly by Fischer, and it is probably this which gave him

[1] [illegible] der fruchtkörper einiger phalloideen, p. 12, taf. 2, fig. 12. In Annales jardin botanique [illegible]

the idea that the pseudoparenchyma develops from the hyphae both of the gleba and of the gelatinous mass of the arm. The hyphae of this narrow layer are, however, in direct connection with the hyphae of the cortical plate and through that with the cortical layer, and stain the same.

In Fig. 21, the small portion *y* of Fig. 20 is shown more highly magnified. On the one side may be seen the gelatinous tissue of the arm, on the other there are the tramal tissue and the hymenial surface with its constricted basidia here without spores. In the space between may be seen the coarser and more irregularly shaped hyphae of cortical nature, marked with irregular lateral inflations and taking on the form of intermediate conditions of pseudoparenchyma. I am unable to find, in any of the many sections examined, hyphae passing from the gelatinous tissue of the arm on the one side or from the gleba on the other into the space between, and there forming pseudoparenchyma by abjointing or constriction of their swollen tips.

The wall of the stipe is now in an instructive stage of development. Serial radial longitudinal sections are shown in Figs. 22 and 23. Two quite distinct tissues are present, as was pointed out in the younger stage. One of these consists of hyphae running in general in a longitudinal direction. These resemble the hyphae of the main cavity of the stipe and those of the gelatinous tissue of the arms. At most places in the section, of which only a small portion has been drawn, these hyphae are in small oblong or linear masses separated from each other by a more deeply stained tissue. The oblong masses lie in chambers which become empty at the time of elongation of the stipe. The deeply stained walls of the chambers are not yet folded; they consist of an early stage of pseudoparenchyma.

Although at some places in these sections and often in whole sections (Fig. 23), the oblong masses of hyphae in the chambers seem to be completely cut off from other masses of similar nature by the chamber walls, yet the examination of the preceding or following sections in the series will show small openings in the walls through which hyphae pass from chamber to chamber. Such an opening is shown at *z*, Fig. 22. This section was next in the series to that represented by Fig. 23.

Sections of the middle and upper portions of the stipe do not show bundles of hyphae passing from the medullary tissue of the main central cavity outward into the chambers of the wall. But near the base fewer layers of chambers occur in the wall, and bundles of hyphae do pass from the medullary tissue of the axis into the chambers through small openings in their walls. Such entrance of the medullary tissue into the chambers may be seen at the points *b''*, Fig. 10, which represents a median longitudinal section through the base of an egg in a still older stage of development.

From the above observations it may be concluded that near the base of the egg, bundles of medullary hyphae pass into the fundament of the stipe, branch there perhaps, and become loosely interwoven; at the place of origin of the arms, these bundles are crowded together more compactly — probably by the extrusions of medullary tissue in forming the gelatinous layers of the peridium — and ascend in six masses, each of which is the fundament of an arm. All of these bundles of hyphae gelatinize and disappear ultimately, and leave empty chambers: hence the course of this tissue from the chambers of the stipe-wall up into the arm is shown by the connection of the cavity of the arm with the cavernous structure of the chambers of the wall of the stipe, reference to which was made in describing the structure of the mature plant.

The second constituent of the wall of the stipe is, in the stage represented by Figs. 22 and 23, more distinctly seen to be in connection with the surrounding sheath of cortical nature than in the younger stage of Figs. 14–17. Its hyphae are differentiating into pseudoparenchyma by the formation of irregular lateral inflations, as described in the case of the wall of the arm.

Fischer has stated for *Clathrus cancellatus* and several Phalleae that the hyphae of the chambers radiate outward and form their pseudoparenchyma walls from their swollen tips, contribution to these walls being also made in various Phalleae by similarly swollen tips from medullary hyphae of the main central portion of the stipe on the one side of the stipe-wall and from the primordial tissue (my cortical sheath) on the other.[1] In thick sections there is somewhat of the appearance which he describes and figures repeatedly, but it is due to the packing together of the pseudoparenchyma next to the surface of the gelatinous tissues — to which reference was made in the case of the arm — and to the impossibility of determining with certainty in such sections the real connection between the cell-like pseudoparenchymatous bodies. But even here I can in no case find a hypha from the medullary tissue of the main central cavity of the stipe or from the chambers of its walls making a distinct connection with the pseudoparenchyma — such a connection as is easily seen between the tramal tissue and the basidia. In sections cut 6 2-3 μ thick, it may be seen that the pseudoparenchymatous bodies run in the plane of the wall and not perpendicularly into it, as would be the case provided they had the origin which Fischer has stated.

The conditions which I have described stand out still more distinctly, when such a thin section, after removal of its paraffin and after being run down to water but not [illegible] the slide, is then treated with a drop of dilute potassium hydrate. The section should be carefully crushed under the cover-glass so as to spread it out somewhat and

[1] [illegible] phalloideen, p. 5, 6, and 36, and fig. 26, 27, and 32; and Zur entwicklungsgesch. der [illegible], p. 17, and fig. 18.

separate its hyphae to a slightly greater extent, and finally stained with aqueous solution of safranin. The hyphae of the chambers will be found quite free from the strands of pseudoparenchyma, while the hyphae of the latter will now be separated sufficiently to show with greater distinctness such conditions of development as have been drawn at x'', Fig. 18.

Final Development

Such an intermediate stage of the pseudoparenchyma leads up to its final condition shown in Fig. 10. The walls of the chambers are no longer straight as in Figs. 22 and 23, but are thrown into folds closely crowded together (Fig. 10, *p*).

The structure of the wall of the stipe affords the clue to the formation of these folds. The branched and interwoven bundles of medullary hyphae *b* make the elongation of the chambers dependent upon the elongation of this medullary tissue during its existence. The more rapid growth of the pseudoparenchyma in the chamber walls tends to make these walls longer than the chambers can become during the existence of their medullary contents. The excess in length of the walls is laid down in the folds.

Elongation of the Stipe.

When the gleba has attained its maturity and the stipe has completed its folded walls, a series of changes occurs in the egg provided external conditions are favorable. Through these changes the elaborately constructed receptaculum bursts from the volva, and rises aloft, conspicuously exposing its spores to the disseminating agency of insects. These changes are:—

a. The gradual elongation of the egg from its nearly spherical form in early life. During the later stages of this elongation, the volva separates from the receptaculum by the splitting of the inner wall of the peridium (*i*, Fig. 9).

b. The gelatinization and disappearance of the medullary tissue occupying the main central part of the stipe, the chambers of its walls, and the interior of the arms. (The beginning of this change is shown by the main central tissue of the stipe in Fig. 9.) This permits

c. The straightening out of the folds in the walls of the chambers.

As a result of these changes, the receptaculum pushes upward against the apex of the peridium, or volva, which becomes thinner there (Fig. 9) and is ruptured finally. The receptaculum then emerges. These changes occur in wet weather.

The straightening out of the folds in the chamber walls of *Phallus caninus* and of *Phallus impudicus* was stated by De Bary to be due, in his opinion, to the inflation of the chambers by the formation of a gas within them.[1] This idea has found its way into the text-books.[2] Such an explanation of the phenomenon has been objected to, and very properly so, by Fischer in a short paper of great importance.[3]

In this article Fischer points out that the chambers are not surrounded by air-tight walls; that all of the chambers are open on one side in some of the forms which he has studied; and that there is no visible indication of the inflation of the chambers during their elongation. From these facts he concludes that the walls are not passive in their straightening out, as De Bary's explanation necessitated.

That they are the active agents he deduces from the forms of the cells at the ends of the folds and from their changes in form when the folds straighten out. He shows that at the inner angle of the fold the cells are wedge-shaped as if by compression, while on the periphery of the fold they are elongated and thin as though stretched out there. Upon placing such folds in certain aqueous solutions of slight density, the turgescence of the cells increases by absorption of the liquid, they become more nearly spherical, and the effect of such change of form both at the inner angle of the fold and at its periphery is to straighten out the fold.

In *Anthurus borealis* the cells of the folds have the forms which Fischer figures and the folds straighten as he states. As the elongation of the stipe in plants of this sort occurs only in wet weather or in damp places, it seems to me that Fischer has offered the true explanation of the rapid elongation of the stipe—so rapid as to give rise to the popular impression that such plants attain their full growth in a night.

The Hymenium.

It has been stated that the hymenial layer lines the chambers of the gleba. The hyphae of the trama give off numerous short lateral branches, the swollen ends of which form the hymenial layer (*h.* Figs. 17 and 20). In the youngest egg of Anthurus these swollen ends were unsegmented and did not yet bear spores, and they stained deeply with the carmine. In the later stages spores were present, and the deeply stained and swollen but nevertheless comparatively small and slender ends of the tramal branches were divided into four or five short cells and constricted at the septa (Fig. 11).

It may be urged that the end cell of this series should be regarded as the true [illegible], but the preparations do not favor such a view. The figure was carefully made

[1] [illegible] physiol. der pilze, I., [illegible] Eng. trans., p. 341.

[2] [illegible] the Fungi, etc. [illegible] Text-book of botany. [illegible] (*c*) Goebel: Outlines of classif. and spec. morph., Eng. trans., p. 139.

[3] Ed. Fischer: Bemerk. über den streckungsvorgang des phalloideen-receptaculums. Mittheilungen der naturforschenden gesellschaft in Bern. 1887. p. 142–157.

with the aid of an Abbé camera lucida, and shows accurately the differences in form between the branched tramal hypha and the constricted basidium. But there are also differences in nature between the two, which are revealed by the action of stains. The tramal hyphae and their short branches as far as the first cell of the basidia stain but very slightly with carmine or eosin, while the 4- and 5-celled basidium stains intensely with these substances and its parts all stain alike, the terminal cell not differing in nature from the three or four below.

This character of the basidia seems to be unique — at least so far as my reading and observation go. Still it may have been overlooked in other cases. It is readily demonstrated by crushing under a cover-glass sections that have been treated with potassium hydrate and then staining them with aqueous solution of eosin.

No cystidia were to be seen. In my Fig. 11, I have omitted drawing the spores on one basidium, but that was for clearness in the figure. The sterigmata are very short, and the spores are borne in a close cluster of from 5 to 8 at the obtuse end of the basidium. The spores are olive-green, simple, ellipsoidal, 3-4 × 1 1-2 μ. Throughout the gleba they all seem to be in about the same stage of development and all ripen together probably. No attempt has been made to germinate them.

Clamp Connections.

A form of clamp connection may be seen in the earlier stages of the egg. It was observed very frequently in the medullary tissue of the axis of the plant and in the gelatinous tissue of the peridium and more rarely in the cortical layer. In the latter case hyphae having such connections showed fewer anastomoses with the other hyphae and were more regular in form than is the case usually with the cortical hyphae. In this form of clamp connection one or both of the adjacent cell ends are very considerably swollen. Fig. 13 *a* shows one of the cases in the cortical layer and Fig. 13 *b*, two in the gelatinous layer of the peridium.

Summary of Development.

1. All of the tissues of the egg arise from internal differentiation of the medullary and cortical tissues of the mycelial strand. In such differentiation

(*a*) The medullary portion gives rise to the column of gelatinous tissue in the main cavity of the stipe, to the more persistent forms of this tissue which constitute the diaphragm and the dome, to the entire mass of the gleba, and to the gelatinous and inner layers of the peridium; while

(*b*) The cortical layer gives rise to the outer wall of the peridium, to the cortical plates (or radial walls), and to the cortical sheath of loose tissue outside of the stipe.

2. The receptaculum is formed by the joint action of both the cortical and medullary tissues. Of these the cortical constituent develops into the pseudoparenchyma of the walls, while the enclosed medullary bundles of the chambers finally become gelatinous and disappear, their most manifest function being apparently that of preventing the elongation of the chambers until the completed formation of the folded walls of pseudoparenchyma has provided a mechanism for quickly raising the gleba aloft at maturity under suitable conditions.

3. The straightening out of the folds in the elongation of the stipe seems to be due to turgescence of the cells at the ends of the folds, as first shown by Fischer, and not due to inflation of the chambers by a gas.

Methods Used.

The material was stained in bulk with Mayer's paracarmine.[1] This penetrated well and gave quite satisfactory results. It was necessary to use an alcoholic stain on account of the gelatinization of the medullary tissues when left in bulk in an aqueous stain for more than a few minutes. After dehydration the material was cleared in oil of cedar-wood or in chloroform and imbedded in paraffin. The sections were mounted on the slide with Mayer's albumen medium. After removal of their paraffin with xylol, they were run down through the grades of alcohol to water and then stained on the slide from 1 to 5 minutes in a dilute aqueous solution of safranin. After washing with water, the series were then mounted in a dilute glycerine consisting of two volumes of concentrated glycerine and one volume of distilled water. An excess of this mounting medium was used, and it was allowed to concentrate for several days by evaporation from under the edge of the cover-glass. Sealing such large mounts is often troublesome. After cleaning they were closed with hot glycerine jelly and then finished with Bell's cement, after the method recommended by Lee.[2]

The attempt was made to stain the sections on the slide when brought to the proper grade of alcohol with the mixture of alcoholic safranin and anilin water, after the formula of Zwaardemaker,[3] but the differential stain obtained was not so satisfactory as with the aqueous safranin.

The use of Canada balsam, in order to save some of the labor of mounting long series in glycerine, had to be given up as the true relations to one another of hyphae lying in different planes were less satisfactorily shown in that medium than in glycerine.

1 Mayer: Mitth. zool. stat. zu Neapel, X, 3. 1892.

3 See Lee: Microtomist's vade-mecum, 3d ed., p.

2 Lee: Microtomist's vade-mecum, 3d ed., p. 252 and 254.

See Lee: Microtomist's vade-mecum, 3d ed., p. 65.

Historical and Systematic Account

There is but little literature upon Anthurus, and what there is has been confined almost wholly to brief systematic descriptions of the mature forms of the few species. The earliest form described was *Lysurus archeri* Berk., collected in J. D. Hooker's Antarctic voyage of discovery, 1839–1843. This form was afterward figured by Berkeley in Flora Tasmaniae, Vol. II., 1860, Tab. 184. From the illustration of an "egg" given there, Fischer was able to decide in 1889 that in Anthurus the arms inclose and arch over the gleba in the young stage.[1] This seems to be all that has been heretofore directly known in regard to young stages of Anthurus.

According to the view of the genus Lysurus presented by Fischer in Saccardo's Sylloge fungorum,[2] *A. borealis* would be considered a Lysurus, for its arms bend inward—not outward.

Patouillard[3] has, however, recently objected to such a view of Lysurus and shows from late studies upon a supply of *L. mokusin* collected in China by Delavay, that the marked characters of that species are the smooth inner faces of the arms and the presence of the gleba upon the outer (externe) faces of the arms. An Anthurus, he states, has its spore mass against the inner faces of the arms. This objection has caused Fischer to modify the characters of the two genera in a late addition to his monograph upon the Phalloideae,[4] so that now he distinguishes Lysurus from Anthurus by the former having the inner faces of its arms smooth and not covered by the gleba, while they are so covered in Anthurus.

Upon such a view of the genera our North American fungus must be regarded as an Anthurus, for the greater portion of the inner face of each arm is cross wrinkled and is in contact with the gleba. It approaches Lysurus in having the lower portion of the inner face of each arm smooth and not covered by the gleba. The erect position of its arms also is like that of *L. mokusin*.

This species thus comes to have an important systematic interest from its closely connecting Lysurus with Anthurus and so with the Clathreae, where Fischer places it.

The fungus is quite distinct from all forms heretofore described and may be regarded as a new species with the following diagnosis :—

[1] Ed. Fischer: Untersuch. z. entwick. der phalloideen. p. 11.

[2] Saccardo: Sylloge fungorum. Vol. 7. p. 22.

[3] Patouillard: Organisation du *Lysurus mokusin* Fr. Journal de botanique, 16 Juillet 1890, p. 252.

[4] Fischer: Neue untersuch. z. vergleich. entwicklungs-geschichte u. systematik der phalloideen. p. 6 and 27.

[illegible] BOREALIS sp. nov. Plates 49 and 50.

Solitary or subcaespitose. Stipe white, clavate, divided above into 6 erect, narrowly lanceolate, hollow arms [illegible] above and with pale flesh-colored backs which are traversed their entire length by a shallow furrow having its surface continuous with the surface of the stipe; cavity of the stipe nearly closed at the base of the arms by a thin diaphragm opening above into a closed chamber with dome-shaped wall even on its inner surface and adherent to the arms for about ½ their length; gleba brownish olive-green, supported upon the dome and closely embraced by the arms; spores simple, olive-green, ellipsoidal, [illegible] × 1½ μ, 5–8 on septate and constricted basidia.

Total height of plant 10–12 cm.; arms about ⅓ of this; greatest diameter of stipe 15 mm.

Hab. Near East Galway, New York (Burt), on a cultivated sandy hillside.

Although in its general aspect this fungus bears a certain external resemblance to *Anthurus australiensis* (Cooke and Massee) Ed. Fischer, as the latter is illustrated by Fischer in "Neue untersuch. phalloideen," Fig. 57, yet it differs from that species in the erect position; in structure of its arms; in having a dome-shaped chamber separated from the cavity of the stipe by a diaphragm; and in its slightly narrower spores.

From the Brazilian species, *A. sanctae-catharinae* Ed. Fischer, it differs in about the same characters and also in its white stipe.

It seems to approach more closely to another South American form, *A. clarazianus* (Müller) Ed. Fischer.[1] It differs from this in being about four or five times as large; in not having the wall of the arms sharply differentiated in structure from that of the stipe; in having its stipe with a circular outline in cross section, while the form described by Spegazzini is noted by Fischer to have been indistinctly hexagonal;[2] and in its smaller spores. Seven arms are sometimes also present in that species.[3]

But it seems to be very distinct from the other species of Anthurus in its approach toward Lysurus. It is the only species of Anthurus at present known in the northern continents.

In conclusion, I desire to express my heartiest thanks to Prof. W. G. Farlow for the use of books from his library and for his direction in this research; and to Prof. R. Thaxter for his critical examination of certain preparations.

EXPLANATION OF THE PLATES.

Figures 4–26 were drawn with the aid of an Abbé camera lucida.

LETTERS COMMON TO ALL THE FIGURES.

[illegible] tissue of axis of plant in young stages—occupies the space of the main central cavity of mature plant.

[illegible] layer of peridium—of medullary origin.

[illegible] peridium.

[illegible] or outer wall of peridium.

[illegible] portions of cortical layer not pushed outward by the extrusion of the medullary masses in the for-[illegible] M

[1] [illegible] Neue untersuch. phalloideen, p. 28, taf [illegible]

[2] Fischer: Untersuch. phalloideen, p. 65.

[3] J. Müller in Flora, 1873, p. 526, and tab. 6, B.

C'', sheath of cortical tissue surrounding the fundament of the stipe.
a, fundament of wall of the stipe, consisting of
  b, hyphae of medullary origin in spaces which become cavities later and
  p, hyphae of cortical origin which differentiate into pseudoparenchyma.
a', fundament of the arm.
  b', gelatinous tissue of arm of same nature and a part of *b*.
  p', pseudoparenchymatous layer of arms of same nature as *p*.
g, gleba.
t, trama.
h, hymenial layer.
n, connection of gelatinous masses of peridium with M and not yet cut off by completion of inner wall of peridium.
d, dome.
j, diaphragm.

PLATE 49.

Fig. 1. A plant which has passed its maturity. The removal or flowing away of the gleba discloses the cross wrinkles of the arms. Natural size.
Fig. 2. Upper portion of a plant just at maturity. Gleba is *in situ* yet. Natural size.
Fig. 3. Two eggs. Natural size.
Fig. 4. Half of upper portion of a plant split longitudinally — the plane of division passing between the arms. Shows cavernous structure of the stipe. *k*, passage connecting adjacent cavities which are at the base of and alternate with the arms. *l*, passage leading into cavity of the arm. 1, sheet-like masses of tramal tissue. x 2½.
Fig. 5. Half of an arm split longitudinally. Same lettering as before. x 2½.
Fig. 6. An egg in an advanced stage of development. Cross sections of this at two planes show the position of the gleba with respect to the arms. Slightly enlarged.
Fig. 7. Cross section of above egg at plane I-I'. Gelatinous tissues are shaded alike. At *q* the separation of the volva from the arms and gleba has already occurred. The cortical plates C' have lost their connection with the arms and also with the cortical layer C. x about 2.
Fig. 8. Another cross section at plane II-II'. x about 2.
Fig. 9. Half of an egg in a very advanced stage of development split longitudinally. Separation of the volva from the receptaculum has taken place at *q*. The cavity of the stipe is also in formation. x 2½.
Fig. 10. Median longitudinal section of an old egg, showing the folded structure of the pseudoparenchyma, *p*. At *b* hyphae of chamber are connected with the medullary tissue *M* of axis; pseudoparenchyma passes over into cortical layer C at *p''*. x 10.
Fig. 11. Portion of a tramal hypha with 3 lateral branches terminating in basidia. The spores are omitted from one basidium. x 860.
Fig. 12. Three spores. x 2400.
Fig. 13. 13*a*, hypha from cortical layer showing enlargements or a form of clamp connections at the septa. x 325. 13*b*, hyphae from gelatinous layer of peridium, showing similar condition. x 325.
Fig. 14. Longitudinal section of the youngest egg found. Lower part of figure was added from second section as the sections were cut very slightly oblique. At *n* the gelatinous masses M are connected with the medullary tissue M. x 17.

PLATE 50.

Fig. 15. Portion of Fig. 14 more highly magnified and from a single section. x 60.
Fig. 16. Cross section of half of the same egg, showing fundament of arm *a'*, cortical plate C', etc. x 17.
Fig. 17. Portion of Fig. 16 showing the series of folds and furrows in the gleba that are developing at the surface of the cavity in which lies the fundament of the arm *a'*. The hymenium is here a palisade-like layer of swollen hyphal ends *h*. The inner wall of the peridium is just beginning its development. x 60.
Fig. 18. Pseudoparenchyma of the stipe in different stages of development. *x* and *x'* are from the egg figured in Figs. 14–17; *x''*, from that of Figs. 20–23. x 400.
Fig. 19. Very young egg of *Clathrus columnatus*, having greatest diameter of 1½ mm. Shows broad longitudinal ridges caused by extrusions of the medullary tissue M. x about 6½.
Fig. 20. Portion of cross section of egg in an intermediate stage of development. A portion of the cortical plate and gelatinous layer that would lengthen the figure 8 cm. has been omitted. x 34.
Fig. 21. Part of wall of the arm from Fig. 20, *y*. Barren basidia are at *h*. x 670.
Fig. 22. Radial longitudinal section of wall of stipe of same egg showing straight-walled chambers and connections *z* of medullary hyphae of one chamber with the other. x 60.
Fig. 23. The following section of the wall. This alone might give the impression that the chambers have no connection with each other. x 60.

INDEX.

ERRATA.

Page 18, line 5 and note 2, *for* Archimantis *read* Lithomantis.

Page 19, line 15, *for* Ledrophora *read* Legnophora.

Page 68, line 20, *for* internomedian *read* externomedian.

Page 138, heading, *for* Sytlactis *read* Stylactis.

Page 150, line 19, *for* arrayed *read* arranged.

Page 171, line 2, *for* figs. 16, 18 *read* figs. 16–18.

Page 240, 2d line of note, *for* Lisyra *read* Sisyra.

Page 299, 9th line from bottom, 1st column, *for* bretonensis *read* bretonense.

Page 323, line 29, *for* cold *read* coal.

Page 323, last line but one, *for* Palephemera *read* Platephemera.

Page 337, line 5, *for* στεφω *read* στρεφω.

Page 347, in centre, *for* Meganthentomum *read* Megathentomum.

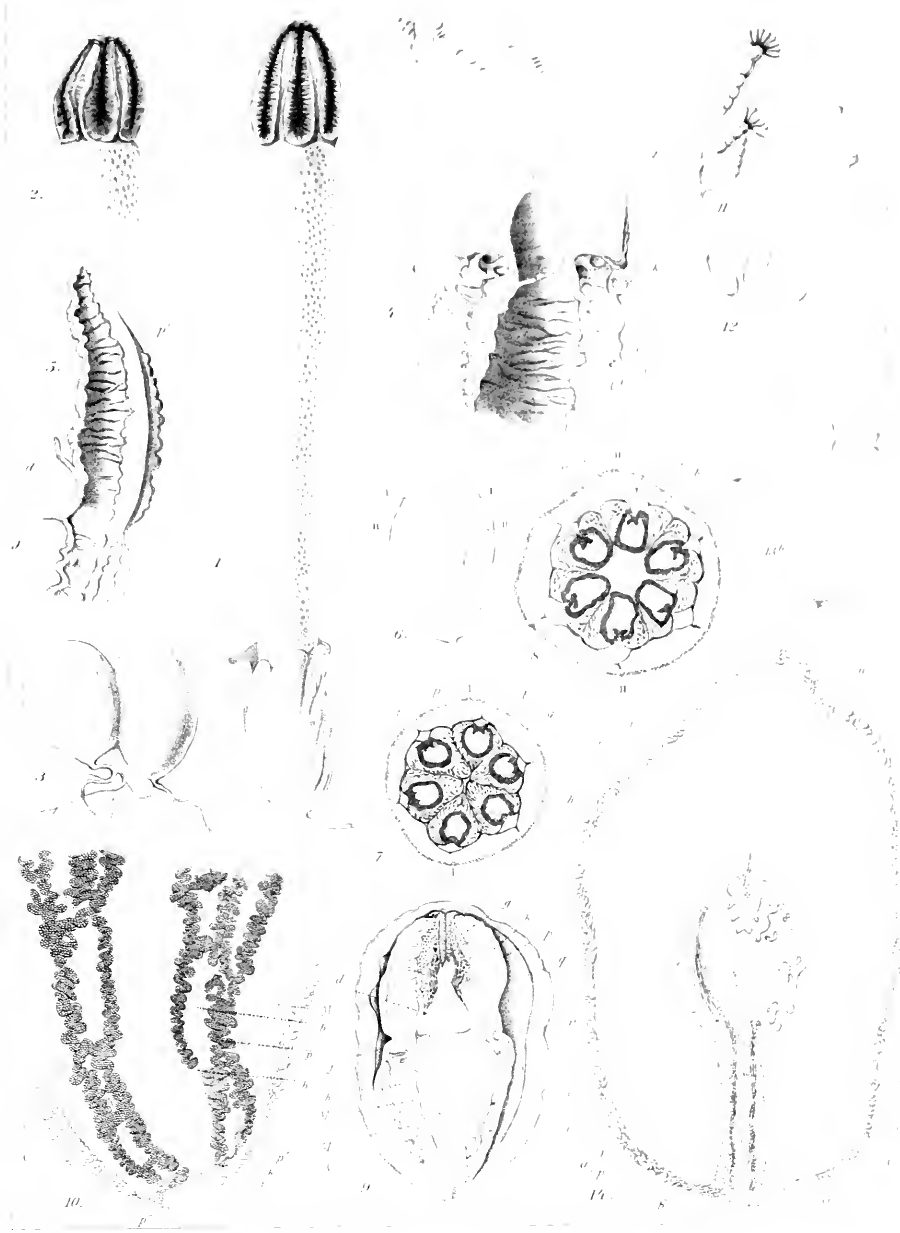
Page 357, line 31, *for* non-existing *read* now existing.

Page 415, 5th line from bottom, *for* Agalma *read* Aglaura.

Page 416, lines 3, 11, 14, 18, *for* Agalma *read* Aglaura

Page 441, 8th line from bottom, *for* size *read* length

NOTE by S. H. Scudder.—By an unfortunate accident, three of the species described in the memoir on Palaeozoic cockroaches have been ascribed to the wrong discoverer and to an incorrect horizon and locality. *Necymylacris heros* (p. 51, pl. 5, fig. 9), *Archimylacris parallelum* (p. 85, pl. 6, fig. 6), and the species described without a name (p. 128, pl. 6, fig. 13), were all discovered by Mr. R. D. Lacoe, and not by Mr. Mansfield, in the neighborhood of Pittston, Penn. *Necymylacris heros*, like the single other species of the same genus, was found in a heavy black shale in the lowest productive coal measures, or the roof shales of vein C. *Archimylacris parallelum* and the other species came from Campbell's ledge, near the bottom of the interconglomerate (Rogers, No. XII). It is due to these gentlemen to state that the mistake is entirely mine.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