PHILOSOPHICAL TRANSACTIONS.

X. The Bakerian Lecture.—*On the Organs of Reproduction, and the Development of the Myriapoda.—First Series. By* George Newport, *Esq., Member of the Royal College of Surgeons, and of the Entomological Society of London. Communicated by* Peter Mark Roget, *M.D., Sec. R.S. &c. &c.*

Received June 17,—Read June 17, 1841.

THE development of the Myriapoda has hitherto been only partially investigated. It is, nevertheless, a subject of great importance to the comparative anatomist, from the remarkable fact that it takes place in a manner entirely different from that of most of the higher Articulata, to some of which the Myriapoda are closely allied both in habits and structure. The true Insecta arrive at their perfect state by an aggregation or apparent diminution in the number of their segments, but the Myriapoda, on the contrary, by a repeated increase of these parts, which in many instances are multiplied to several times their original number. This addition of segments, during the growth of the animal, occurs throughout the whole class, and is one of its chief characteristics. This fact was first noticed long ago by Degeer, but since the period of his observations nothing further was added to our knowledge until it was fully confirmed by the careful investigations of Savi, and also by the more recent labours of Brandt, Gervais, and Waga. But excellent as are the observations of these naturalists, some of the most important circumstances connected with them have been entirely overlooked, both as regards the condition of the embryo on leaving the ovum, and also as regards the manner in which the new segments are developed. M. Gervais* has pointed out a circumstance in which the Scolopendradæ differ from the Iulidæ in the development of the legs, but no precise account, so far as I have been able to ascertain, has been given of the production of the segments. In the observations which I now have the honour of submitting to the Royal Society, I propose, first, to examine the organs of reproduction, and then to show the various changes as they occur in the development of *Iulus terrestris*, one of the commonest species of the Iulidæ of this country.

* Annales des Sciences Natur., tom. vii. Janvier 1837, p. 35, &c.

1. *Organs of Reproduction.*

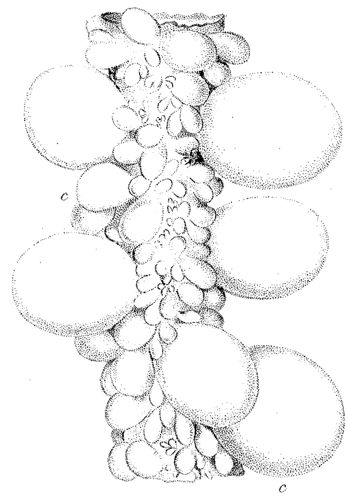
The reproductive parts in Iulus are exceedingly interesting on account of their simplicity of structure. TREVIRANUS* has described them in the male as two elongated tubes which terminate in separate orifices behind the seventh pair of legs, without any external organ of intromission. In the female, he says, they are composed of a long ovary, formed of two knots of eggs which extend from its outlet in the fourth segment, to its termination beneath the alimentary canal, near the anus; but in this account he has entirely overlooked the essential parts of these organs in both sexes.

In the male of *Iulus terrestris*, the reproductive organs (Plate III. fig. 1.) are two elongated, and sometimes partially convoluted tubes, placed side by side beneath the alimentary canal, immediately above the nervous system, and between the two large salivary vessels. Anteriorly (*a*), they terminate in two organs of intromission, which pass out at the under surface of the seventh segment by distinct orifices, behind the seventh pair of legs. Posteriorly, they extend backwards as far as the middle of the colon. In the anterior third of their course they lie close together (*b*), but afterwards separate, become smaller, and have developed from their sides, at short distances, a number of minute glandular cæca (*c c*). Soon after separating they are again connected transversely by three short ducts (*d d d*), by means of which the two organs communicate freely with each other. Two of these ducts are situated anterior, and the third posterior to the first pair of cæca. In the posterior part of the body, each tube is divided into two portions, covered with cæca, and between them there also appear to be some transverse communications, as in the anterior parts of the tubes, but of this I am not fully satisfied. The cæca are of an hour-glass form, and may perhaps be regarded as the proper testes of the animal. They are each connected to the larger, or efferential tubes, by a short narrow duct (*e*), the proper efferential vessel of each cæcum or testis. The delicacy and transparency of these parts in an immature individual, allow their structure to be examined with great facility (fig. 2.). They are simple constricted sacs, lined with a thickened mucous membrane (*f*), and are folds or intussusceptions of the whole muscular, as well as mucous lining of the greater tubes, and from the structure of their interior seem to perform a secretory or glandular function. I have been unable to trace any tubes continued from their larger or cæcal terminations, but have seen many minute vessels distributed over their exterior surface (*g*), that appear to convey a fluid, probably for the purposes of secretion. At first I regarded all these as tracheal vessels, but this cannot indeed be the case, as many of them anastomose with other similar vessels connected with the adipose tissue. On examining the sacs by transmitted light, their interior is distinctly seen to be filled with a fine granulous fluid (*h*). In those sacs which are nearest the posterior extremity of the organs, the fluid is thin and transparent; but that which is contained in the large tubes, near their anterior termi-

* Vermischte Schriften Anatomischen und Physiologischen Inhalt. Bremen, 1817.

Organs of Reproduction in Myriapoda. (Julus.)

Fig. 5.



magnified about 30 diameters.

Fig. 7.

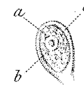


Fig. 8.

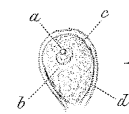


Fig. 9.

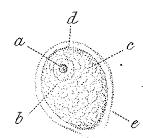


Fig. 10.

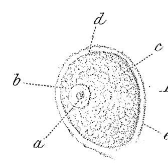
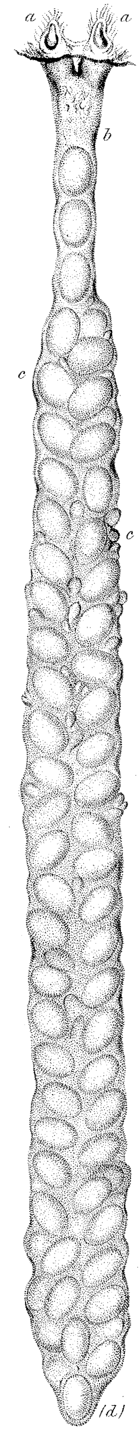


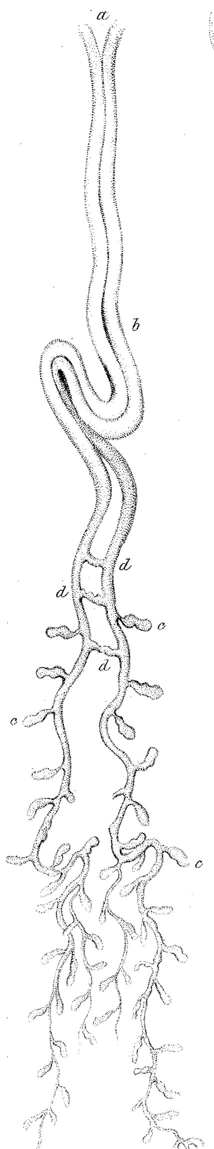
Fig. 11.

Fig. 4.



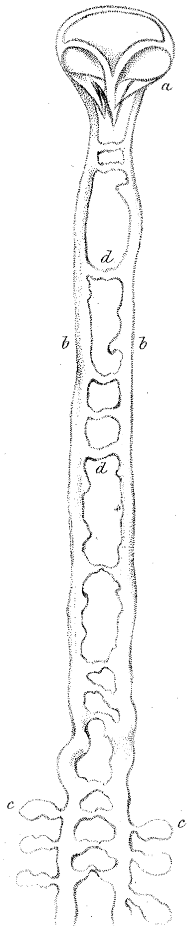
6 diameters.

Fig. 1.



6 diameters

Fig. 3.



4 diameters.

Fig. 6.

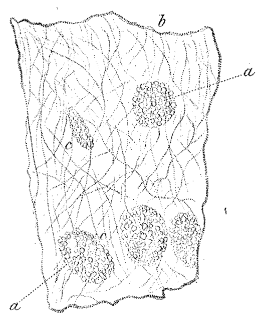
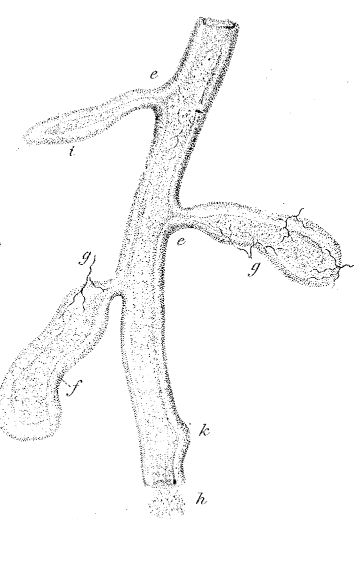


Fig. 2.



G. Newport, del.

J. Basire, sc.

nation, is thicker and more opake the nearer it lies to their outlet. In those individuals which have not arrived at their full growth, many of the sacs are only partially developed. Some of them are narrow, elongated, and have not yet begun to secrete (*i*); and others are only beginning to make their appearance at the sides of the tubes (*k*). In all of them, the interior or mucous lining is distinctly seen to be continuous with that of the large efferential tubes, and in those which appear to be secreting, the base of each vesicle is constricted by the mucous lining within, which seems to form a valve (*e*).

The general structure of the generative organs is very simple throughout the whole of the Iulidæ, but many curious peculiarities occur in the larger species. Thus, in one of the African types, the double organ of intromission (fig. 3. *a*) is prehensile, each part having the form of a distinct claw, between the moveable joints of which passes out the elongated half-corneous penis. These parts are covered in anteriorly by a horny valve, somewhat of a triangular form, and the whole occupies an oval space on the under surface of the seventh segment, corresponding to that usually occupied by the legs. Anteriorly, the two large efferential ducts (*b*) terminate in the penis in very fine tubes, beyond which they become more and more dilated, but instead of being close together, they are placed at some distance from each other throughout their whole course, and lie, one on each side, above the nervous cord, but are connected by transverse ducts from near their very outlet in the penis to their lateral development into cæca (*c*). In this part of their course they would seem to perform the office, not only of efferential ducts, but also of receptacles for the seminal fluid, with which both the transverse ducts (*d*), and certain short dilatations from their inner side, are greatly distended. In one species, *Iulus* ——? I found fourteen of these transverse ducts, and in another, more than twenty. In other respects, these organs of reproduction, in the larger species, resemble those of *Iulus terrestris*, being covered with an abundance of short cæca. In this part of their structure they approach closely to some of the *Annelida*, in which, as in the common Leech, the cæca of the male organs are regarded as accessory vesiculæ seminales. But the great number of these cæca in Iulus, and the presumed absence of other structures which may be regarded as the proper testes of the animal, together with the greatly distended condition of the transverse ducts and efferential tubes towards their anterior part, have inclined me to the opinion now advanced respecting their true nature; although from their analogy with the Annelida, and also from the circumstance of my not having yet been able to follow out the main ducts to their commencement, the subject must still be regarded as open to further inquiry. With regard to the product of secretion in these organs, I have never yet found anything but a granulous fluid in the cæca, apparently similar to the granules in the higher animals, from which spermatozoa are produced; but this might have arisen from the immature recent specimens I was alone able to obtain. It would be interesting to ascertain whether these germs of spermatozoa are produced in the cæca, as there seems reason to believe, as we shall presently find that the ova in the female are secreted in sacs which appear to be analogous to these cæca in the male organs. I am inclined to think that the spermatozoa are not developed until the granulous fluid has passed into the efferential ducts at the season of impregnation.

In the female the organs of reproduction (fig. 4.) are as simple as those of the male. They consist of a single elongated bag, or oviduct, covered on its exterior surface with a very great number of ovisacs or cæca, of various sizes, each of which secretes but a single ovum. This oviduct extends backwards beneath the alimentary canal from its double vaginal outlet (*a a*) in the fourth segment behind the second pair of legs, as far as the posterior part of the rectum, close to the anus, where it ends in a cul de sac (*d*). It is most nearly in contact with the alimentary canal on its upper surface, but is separated from it by adipose tissue; in the pregnant female it is smooth and distended with ova, that have passed into it from the ovisacs, and are ready to be deposited immediately after intercourse with the male. The ova at the anal extremity of the duct are as perfect as those near the vaginal outlets. The oviduct contains in its cavity at least from seventy to eighty of these perfect eggs, awaiting impregnation, arranged in two or more irregular rows, and greatly distending its sides. In some of the larger species of the genus there are four, and in others five rows of eggs, the number of which is much greater than in our native species. TREVIRANUS* merely described the ovary as formed of two rows of eggs, but the proper ovaries or ovisacs entirely escaped his observation. The ovisacs are distributed thickly, to the number of many hundreds, over the whole exterior of the oviduct (fig. 4 and 5. *c c*), from its posterior or cæcal extremity to within a short distance of its vaginal outlets. Each ovisac, whatever be its state of development, contains but a single ovum, every part of which is produced in it, from the germinal vesicle, in the most rudimentary form, to the yelk, albuminous fluid and shell. This fact deserves particular consideration. A large proportion of the ova in their ovisacs never arrive at maturity, but are retarded in their growth by the more rapid development of others that are near them; so that on examining an oviduct partially distended with ova, the greater number of ovisacs, in different states of development, are at the sides, and on the under surface of the duct, in parts which correspond to the interstices between the fully developed eggs that have passed into the oviduct, or are still forming on its exterior. One row of ovisacs usually exists on each side of the duct, near its upper part, but most of the ovisacs in the course of development are at its sides. The structure of the duct, and of the numerous ovisacs, is best seen in those specimens which have not yet arrived at maturity, or in those which have just deposited one laying of eggs. In these individuals the oviduct (*b*, *c*), to within a short distance of its division into two outlets, is studded with minute ovisacs, each filled with the rudiments of its minute ovum. Its general appearance in a female that has recently deposited its eggs, is completely botruoidal (fig. 5.), very like the ovary of

* *Loc. cit.*

Birds, some ova being always fully developed, and ready to pass into the oviduct, while others are in various stages of development, many of which are imperceptible, excepting with the aid of a powerful lens.

But the most remarkable condition of the female organs is their double vaginal outlet (*a a*), as in Crustacea, although the oviduct itself is a single tube until near its termination (*b*), where it is divided into two short canals, which, from a slight opacity at their base, where they join the single duct, appear, when seen by transmitted light, to be separated from it by a valve, or duplicature of the lining mucous membrane. The vaginal orifices (*a a*) are simply two nipple-shaped portions of the tegument, with somewhat oval apertures, surrounded by a corneous ring, from which is developed a circle of minute hairs. Internally these apertures are closed by a soft thickened membrane: they are situated on the under surface of the fourth segment of the body, and correspond in that to the insertions of the legs in the third segment.

In their general structure the organs of reproduction in the female Iulus present some analogies to those of *Melöe* and *Forficula* among insects, in which the single ovisacs are arranged on the outside of a large oviduct, into which all the matured ova are passed, to be deposited at one act, as in *Iulus*; but they differ from these genera in the structure of their vaginal outlets being double, as in *Crustacea* and *Arachnida*; and differ again from the last in the remarkable fact, that throughout nearly its whole extent the oviduct is a single sac, and divides only into two canals, one of which passes on each side of the nervous cord, immediately before it arrives at its termination. It is difficult to give a reason for this peculiar conformation. May it be connected with a necessity for great rapidity in the act of depositing the ova required by this singular tribe of Invertebrata, the only apparent explanation of this peculiarity?

The situation of these organs beneath the alimentary canal, and their separation from it by the interposition of the adipose tissue, extended in the manner of a peritoneal coat, has already been stated. This adipose tissue, formed of vesicles filled with fat, as in insects, is most extended in the course of the muscular bands that pass down from the dorsal vessel, on each side of the segments, until they arrive at the upper surface of the oviduct. In the course of these bands there seem reasons for suspecting that vessels also exist, as they are proved to do in the *Annelida*; and that the ovaries are supplied, by these means, with the circulatory fluid directly from the dorsal vessel. The division of the dorsal vessel at its anterior part into distinct vessels, and the connexion of these with a large vessel extending along the upper surface of the nervous cord in *Scolopendra*, as seen both by Mr. Lord* and myself†, strongly support this opinion.

The simplicity of these organs in Iulus beautifully exemplifies the remarkable similarity of structure which the labours of anatomists have shown to exist between these parts in the two sexes. In both male and female the outlet to the organs is

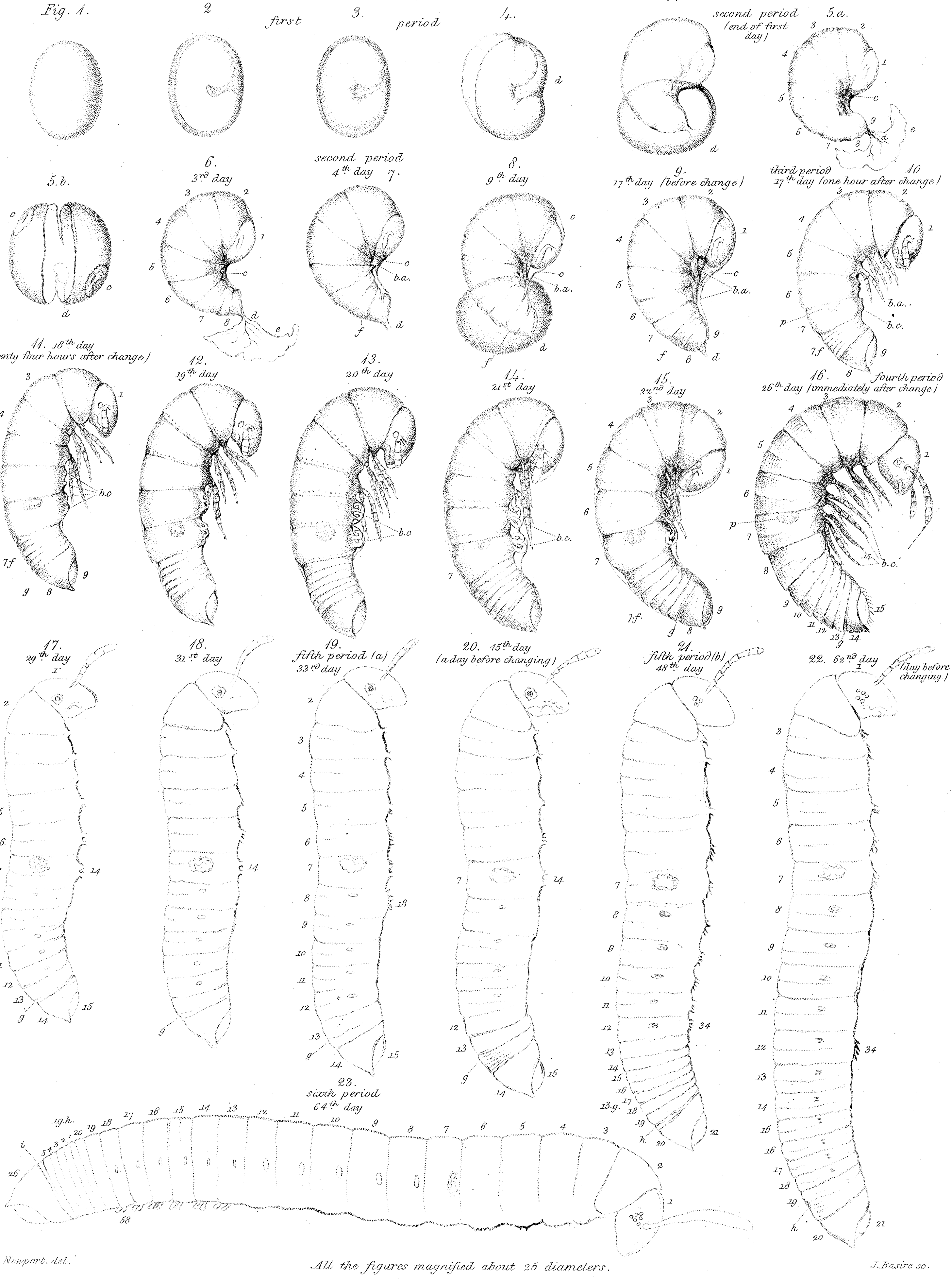
* Medical Gazette, March 3, 1838, vol. xxi. p. 892.

† Ibid. March 17, 1838, p. 970.

double, and also the excretory duct, for a short distance. In the female the ducts are soon united, and continue so throughout their whole course, forming a single large sac, covered externally with a large number of cæca, or ovisacs, in each of which the rudiments of a germ are secreted. In the male the ducts continue single, but communicate with each other transversely, thus forming a common cavity with a double outlet, as in the female. Externally they are also covered with cæca, apparently the analogues of the ovisacs; for like them they contain their peculiar fluid, and perhaps future spermatozoon that is believed to be essential to excite the development of the germ in the female. This uniformity of the organs in the two sexes, is further illustrated by the circumstance, that when the secretory process is complete, the fluid passes into the large efferential ducts in the male, as the ova are passed into the great oviduct of the female. These parts agree still more curiously in the entire absence of a *spermatheca* in the female, for the reception of the male fluid, and of distinct *vesiculæ seminales* in the male, for retaining it after it is secreted, the want of which in the former sex seems to indicate that the ova are deposited immediately after, or at the moment of impregnation; since, in true insects, in most of those instances in which the ova are deposited quickly after the coitus, there is either no spermatheca, or one that is but imperfectly developed.

2. *Structure of the Ovum.*

The existence of the ovisacs in Iulus as single, isolated capsules, on the exterior of the oviduct, in each of which a single egg is produced, is particularly favourable to a minute examination of the ovum in all its states, especially as ova are found at the same time in every stage of development (fig. 5. *c c*). The most rudimentary condition of the ovisacs I have yet seen was observed on examining, by transmitted light, part of an oviduct that had been placed for twenty-four hours in spirits of wine, and afterwards dissected in water. In this (fig. 6.) the smallest ovisacs appeared like very minute glandiform bodies, developed, as it were, directly from the structure of the duct itself (*c c*), in which the rudiments of the future egg had begun to be produced. The smallest of these bodies were of an elongated shape, and not more than three, or at most four, blood-globules in diameter. They appeared to have distinct parietes, and to be filled with very minute graniform cells of a uniform size, slightly opake, and of a yellow colour. The diameter of these cells, as nearly as I could ascertain by direct comparison, was equal to about one third of that of a blood-globule. In the midst of these cells there was a larger, but much more delicate structure, of a circular form (*a*), and equal in size to about two of the cells, but whether this was the proper germinal vesicle, or its macula, [?] it was difficult to determine. Other sacs in the duct, which were twice the size of these, were filled with similar contents. From the opacity and yellow colour of these graniform cells, it was evident that they constituted the yelk in one of its earliest stages. I have never yet seen these peculiar cells absent in any of the ovisacs, even in their most rudimentary



All the figures magnified about 25 diameters.

G. Newport del. J. Basire sc.

condition. They have always exhibited the same yellow colour, with only a slight difference of opacity. At a later stage of development the whole appear to be inclosed in a distinct membrane, the *membrana vitelli* (fig. 11. *d*), and even at this early period (fig. 8.) the membrane may be regarded as in the course of formation, as seems to be indicated by the fact, that the cells always cohere together when the specimen has been placed in spirits of wine, and afterwards allowed to remain for some time in water. In these cases the ovisac becomes distended by the imbibition of fluid, as is proved by the existence of a clear transparent space between the interior of the ovisac (figs. 7 to 11. *d*) and the yelk (*e*), the cells of which do not separate, but together retain the form of a single mass unaltered, even when pressed in different directions between plates of talc beneath the microscope. When the ova are a little further advanced (fig. 9.), the same yellow-coloured graniform cells compose the yelks; but they are a little darker in colour, larger, and more distinctly exhibit a granular structure in their interior: they closely resemble in form and structure the vesicles of the yelk of the higher animals, as described in the excellent researches of Dr. Martin Barry*. The membrane of the yelk (*d*) at this period is more strongly marked, and exhibits a distinct outline, when treated as above described; and the germinal vesicle is much more apparent (*a*, *b*). At this stage of the ovum, the outline of the vesicle is more distinct than in the previous stages, and this body is slightly larger. The *macula* (*a*) is of a perfectly globular form, and is apparently covered by a separate membrane†. It is very distinct, and is formed by an aggregation of minute cells, or vesicles, surrounded by fluid. In a more advanced stage of development the vesicle is surrounded at a little distance by an outer ring, which exists in all the ova in the succeeding stages, but is not seen in the first stages of the ovum.

When a perfect egg that has passed into the oviduct, and is ready to be deposited, has been placed in spirits of wine, and is afterwards examined beneath the microscope, there are seen on the outside of its opake shell one or more large spots (Plate IV. fig. 5. *b*. *c c*), which appear to be occasioned by some circumstance connected with the formation of the shell in the oviduct or ovary. These spots are large and oval, are formed by concentric rings, and appear to be the result of incomplete depositions of the different layers of material of which the shell is composed. In the vicinity of the spots within the egg I have usually found some aggregated oil-globules. The yelk is of a light yellow colour, and occupies nearly the whole of the interior, there being only a very small space around it, and a very slight quantity of albumen. The form of the yelk within the shell, when the egg has remained for some time in spirits of wine, is irregular. At one end it becomes obtuse, and rounded; at the other incurved, and a little pointed. On one surface it is large and convex, and on the opposite concave or excavated. In the middle of the concavity is the transparent globular vesicle, the proper germ vesicle, considerably enlarged, and presenting the

* Philosophical Transactions, 1838, 1839, 1840.

† See Wagner's Physiology, translated by Dr. Willis, Part I. 1841, p. 41, note 48.

appearance of an air-bubble; it projects from the surface of the yelk, and the cavity in which it is inserted. When viewed laterally, in those ova which have been first placed in spirit, and afterwards in water, it is very much elevated above the yelk into part of the clear space. In one instance I observed on the upper surface of this vesicle an aggregation of globules, apparently oil-globules, about six in number. Around the yelk, after the egg has been placed in water, there is a free space, as in the immature ovum. When the perfect ovum, soon after its impregnation and deposition, is placed for a few minutes in rectified spirits of wine, it begins to collapse on one side in the long axis of the egg: that surface is thus rendered concave. Sometimes the egg contracts also at one extremity, but this is only to a small extent when compared with the other. On watching this contraction of the egg and its yelk beneath the microscope, while it remains in rectified spirits of wine, the yelk is seen to retire from the shell towards the centre of the egg; and its external surface acquires a translucent appearance, resembling the albuminous space in the egg of the Bird. During this contraction, it may be seen, through the sides of the yelk, that the cells are of an uniform size, and retire slowly towards the centre. When the egg has remained about half an hour in rectified spirit, the whole interior has become translucent, although it is perfectly opake in the natural state, excepting a small part near the centre, the locality of the germinal vesicle. That those parts of the shell which collapse are the thinnest is proved by several observations. If the egg, when entirely contracted, is put into cold water, it again becomes opake, and the shell expands to its original dimensions and form; but the yelk does not change its appearance, it retains the shape it has taken in the spirit. From this expansion of the shell we may reasonably conclude that fluid is imbibed through it, and occupies the space between it and the yelk, and that this space is lined by distinct membranes; the *membrana vitelli* before noticed in the early stages of the ovum, and the *membrana externa* or *chorion* (*b*) that lines the interior of the shell. These membranes exist in the egg at the period when the embryo is complete; the membrana externa, or proper chorion, still lining the interior of the shell, and the membrana vitelli constituting the amnion which incloses the young animal. We are thus able to identify in these low forms of Articulata the parts that are known to exist in the most perfect animals, and in addition to them, the external envelope or shell. It is worthy of remark, that the whole of these structures are formed in the ovisac, in which, as before shown, only one egg is secreted at the same time, and is then passed, complete in all its parts, into the oviduct, to be impregnated preparatory to the production of the new being.

3. *Deposition of the Ova, and Habits of the Species.*

I have never yet seen the Iulidæ *in coitu*, but from the fact that the oviduct in the female, at the season of depositing her eggs, is always completely filled with them, all equally developed, as well as from the entire absence of a spermatheca, we may reasonably conclude that the act is of short duration, and that oviposition takes place very soon after impregnation. From the circumstance that many eggs are far advanced when the animals are collected in the autumn, I at first supposed that season to be the proper period for depositing the eggs; but the facts now about to be stated induce me to believe that this process takes place very early in the spring.

In order to observe the habits of these animals, I collected from thirty to forty of them in the beginning of October, when they were preparing to hybernate, and placed them in a tin box, covered at the bottom with clay and sand mixed with vegetable mould, the soil in which they were captured. I fed them, according to the directions of Professor Waga in his interesting experiments*, with decaying leaves and slices of apple. In this way they were preserved perfectly healthy, and as winter approached, gradually passed into a state of hybernation. At the end of December, when the weather was severe, and the temperature of the room in which my specimens were kept was between 30° Fahr. and 40° Fahr., they were collected together in a heap, each coiled up in a circle between the folds of dried leaves, as if in a perfect state of hybernation. They were not aroused by the opening of the box. The temperature in which they had been kept, up to this time, had seldom been lower than 38° Fahr. On the 13th of January, when the temperature of the room was 41° Fahr., some of them were in a much more complete state of hybernation. A few were still coiled up between the dried leaves, and on opening the box became slightly disturbed, and crawled about very slowly; but others had penetrated the moistened clay at the bottom of the box, each one having formed for itself a circular cavity, in which it lay coiled up in a spiral form, in a state of rest, from which it was aroused with much difficulty. In this situation they remained for many days of exceedingly cold weather, during which the temperature of the room in which they were placed was for some time so low as 28° Fahr. On the 24th of February they were still in the same state, some of them being coiled up between the leaves, while others remained in their circular holes in the clay. A few days after this, the weather having suddenly become warmer, they began to arouse from their hybernation, moved actively about, and again took food. On the sixth of March they were still active and healthy, and, much to my satisfaction, I now discovered, in a little circular cavity at the bottom of one of the holes in the clay, a large packet of eggs, from sixty to seventy in number, that adhered loosely together, and seemed to have been very recently deposited. They were of a yellowish white colour, of an obtuse oval shape, and about the size of the seeds of the wild poppy, which they much resemble. A second packet of eggs was deposited in a similar manner on the 25th of March, and subsequently to this many other packets through the months of March, April and May, as was also observed by Professor Waga in his investigations; so that the spring months seem to be the season of oviposition.

The habits of Iulidæ in regard to the deposition of their ova are somewhat peculiar.

* Revue Zoologique, par la Société Cuvierienne, No. 3, Mars 1839, p. 76.

WAGA has already remarked, that although a moist locality is necessary to the health of these animals, it is prejudicial to them at the season of undergoing their changes, and is then even more fatal to them than a very dry one. I am fully satisfied of the correctness of this observation. Deterred by this instinct, the Iulus will not deposit her eggs, when in confinement, if the soil be too much moistened, nor if it be allowed to become too dry, while she is particularly careful to exclude them from light, by depositing them in a burrow in the middle of the soil, as far as possible removed from the sides of her prison, if this happen to be a glass vessel. She is also exceedingly anxious to prevent the accession of atmospheric air, and carefully closes the entrance to her burrow. The manner in which she proceeds with her labours is curious. Having excavated a little cylindrical hole to the depth of about an inch, and only just large enough to admit her body, she forms at the bottom of it a little circular cell or chamber, by digging out the soil grain by grain with her mandibles and anterior pair of feet. I have seen her busily employed in this part of her labours. When she has excavated the burrow to its proper depth, she remains for a few minutes with her head and the anterior half or two thirds of her body in the hole, as if resting from her toils, with the posterior part exposed on the surface, to enable her to cling by her feet to its margin, and thus afford her support in bringing up the soil she is removing from the bottom. Having continued in this situation for a few minutes, she again resumes her labours. In about a minute she gradually withdraws herself backwards from the hole, bringing up with her a little pellet of moistened clay, which she holds between her first pair of legs and under surface of the head. As soon as it is brought to the margin of the hole, it is passed backwards by these to the second pair, and so onwards to the next in succession as it reaches them, until it is removed entirely out of the way. She then immediately re-enters the hole, and this operation is repeated many times, until she has excavated a chamber at the bottom sufficient for her purpose. In each instance the pellet of clay is saturated with fluid, which appears to be supplied for the purpose by the large salivary glands of the animal, the chief function of which thus appears to be to furnish a great quantity of solvent fluid, to enable the parent the more easily to excavate the chamber intended for the residence of her future progeny in their most helpless, and, as we shall presently see, almost vegetative condition. Having accomplished this part of her labour she remains for some time at rest, with the greater portion of her body concealed in the burrow, and soon afterwards begins to deposit her eggs. When this is finished she immediately sets about the completion of her labours, by carefully closing up the entrance of the burrow. This she does with clay thoroughly moistened to form a thick paste, which she gently presses into the entrance, and fills up nearly to a level with the surface of the soil, thus not only preventing the intrusion of enemies, but also protecting the eggs from the prejudicial influence of the atmosphere, by exposure to which they quickly perish.

When the egg is examined immediately after it has been deposited, it is highly translucent, but soon becomes more opake. Its shell is soft and elastic, and, when exposed to the air, quickly becomes dry and shrivelled. It is on this account very difficult to preserve it to watch the changes in the embryo. Of at least a dozen packets of eggs which I obtained this spring, I have succeeded in rearing only one, which happened to be the packet first deposited, as just described. It is owing, probably, to this difficulty in rearing the eggs and the young of the Iulidæ, that the changes of these animals have been so imperfectly known, and that so much want of precision has been found in the observations of those who have most attended to this subject. Thus DEGEER, who first watched the development of these animals, describes them as possessing six legs when newly hatched*, while M. SAVI states that they are completely apodal†; and WAGA‡, in his excellent observations on this class, confirms the statements of SAVI, but is exceedingly vague in parts of his account of the changes, and has entirely overlooked many most important facts in regard to the production of the new segments.

In my own investigations these difficulties were in part guarded against by filling a thin glass tube with moistened clay, in which a little cavity was formed for the eggs close to the glass, and when the eggs had been carefully removed into it the hole was closed up with clay, and also the tube with a cork. By this means the eggs could be watched from day to day, with a common lens, through the glass, without being exposed to the atmosphere. In this way the changes were easily observed; and one or more eggs were removed from time to time for closer inspection beneath the microscope, care being taken always to close up immediately the hole in the clay. The specimens were examined both in the recent state, and also after they had remained a few hours in spirit of wine, so that the changes were accurately noticed.

The time occupied by the development of these animals extends through many weeks. It is divisible into separate *periods*, which are most distinctly marked, but the extent of which is influenced by external circumstances; and although in general of a certain duration, it is more or less hastened, as in many true insects, by an abundance or deficiency of food, and above all by the temperature of the surrounding medium. I have been unable, from accidental loss of specimens, as well as from the time required for their completion necessarily extending far beyond the present period, to observe the whole of the changes as they occur throughout the entire life of the species, but nevertheless have been able to extend my investigations sufficiently far to enable me to record some remarkable facts, the occurrence of which, I have distinctly ascertained, continues to the full development of the species, and indicates the existence of one general law or principle in the growth of this class of animals.

* Mémoires, tom. vii. p. 582.

† Observazioni per servire alla storia di una specie di Iulus communissima, *Bologna*, 1817. Bulletin des Sciences Naturelles, tom. xii. Dec. 1823. Memorie Scientificke de Paolo Savi Professore, &c. Decade 1ma Pisa, 1828.

‡ *Loc. cit.*

4. *Evolution of the Embryo.*

The *first period* in the evolution of the embryo extends from the deposition of the egg to the gradual bursting of the shell, and exposure of the embryo within it.

In my observations this period extended from the morning of the 6th of March, a few hours after the eggs had been laid, to the 31st of the same month, a period of twenty-five entire days. The atmosphere of the room in which the eggs remained, varied throughout the whole time only from about 50° to 60° FAHR. It has been already seen that the egg of Iulus contains all the primary parts of the ovum of Vertebrata while still in the ovisac, and that the chief alteration the egg undergoes, after it has acquired a size large enough to be recognizable by the naked eye, is simply an increase of its whole bulk.

I can offer but few observations on the earlier changes in the egg after impregnation, a subject already deeply investigated in other classes. I noticed, however, that there was considerable alteration in the appearance of the graniform cells of the yelk within the *first day* after the egg was deposited. They varied much in size towards the end of the day, some of them being much larger than others. The smaller ones were exceedingly numerous, less globular in form, more opake and granular, and adhered together, as if by a tenacious mucus, more firmly than in the unimpregnated egg, but I could not yet observe any trace of the embryo. The shell was still soft and elastic, and the egg became shrivelled and dried up if exposed to the air only for a few minutes. On the *second day* there was still no marked difference in the external appearance, but in the interior the whole yelk had become firmer, and the cells cohered more together, and I thought I could perceive some faint indications of the future embryo, composed entirely of large and small cells. On the *third day* the egg exhibited no further perceptible change; but on the *fourth* its contents were distinctly less fluid than at any preceding period, and the cells were more globular and larger. This was very distinct both in regard to the larger as well as the smaller cells. The whole of them were more closely aggregated together, and much more distinct beneath the microscope. Up to this period I had not satisfactorily observed the outline of the embryo, but there was now a little granular mass on one side of the shell, which I was inclined to regard as the future being. The exterior of the shell had also become more firm and less elastic. Unfortunately, at this period I was accidentally prevented from continuing my observations, which I was unable to resume until the 25th of March, the *nineteenth day* after the egg was deposited. There was now a complete alteration in its form. It was more obtuse at both ends, and had become much larger. This enlargement of the impregnated egg, I have constantly observed in the eggs of *Melolontha*, *Melöe* and *Athalia*, in all of which the shell is elastic. At this period the outline of the embryo coiled up within the shell, and nearly filling the whole interior, was very distinct (Plate IV. fig. 2.). On one side there was a clear transparent space extending about half way across the shell, indicating the distance between the inflected head and tail of the embryo, the body of which was composed entirely of cells, a little larger, and more closely aggregated together than in the preceding examination; but there were no rudiments of limbs, or even of a division of the body into distinct segments. The shell had acquired more firmness, but the egg still contracted, and dried up quickly when exposed to the air for a few minutes. On the following day, the *twentieth* from the deposition of the egg, the outline of the embryo was more apparent (fig. 3.), and on its concave, or ventral surface, there were faint traces of a division of the body into six segments. Up to this period I was unable to detect any funis or umbilical cord to the embryo, a structure of which I was particularly in search, and which I was aware had been seen by RATHKE in Crustacea. When the egg was examined in rectified spirit, the outline of the embryo was rendered more distinct, especially at its extremities, and its whole body was contracted so as to leave a space between it and the shell. It was still formed of cells of different sizes. From this time, to the bursting of the shell, the egg became every day larger, until the morning of the 31st of March, the *twenty-fifth day* from the deposition of the egg, when it was greatly distended, and began to assume a kidney-shaped appearance (fig. 4.); that side of it which corresponded to the ventral surface of the embryo then became a little concave, and the opposite, which corresponded to the dorsal surface, much more convex. The shell was now bursting longitudinally in the median line of the dorsal surface, and the back of the soft and perfectly white embryo was gradually pressing through the opening. The young being was now entering a new state. Its body had exhausted the nourishment supplied to it by the yelk, and it had thus arrived at the termination of the first period of its development, a period of twenty-five days.

In the *second period of development* the embryo is exposed to a new medium, and perhaps derives the means of its further growth from external sources, although it is still enveloped in the fœtal membranes, and retains its connexion with the shell.

The apodal condition of the young Iulus at the bursting of its shell, has already been noticed by SAVI and WAGA, the latter of whom refers also to its extremely delicate and motionless state; but both of these naturalists have overlooked the remarkable fact of its remaining for many days connected to the shell by means of a distinct funis (*d*), and also of its being still inclosed in the *amnion*, the proper fœtal covering.

The liberation of the embryo by the bursting of its shell is a remarkably slow process, as compared with the escape of other animals from the egg. In my observations from ten to twelve hours elapsed before the body of the embryo was so far liberated as to remain only partially inclosed between the two halves of the shell (fig. 5.), to the interior of which it was still attached by its pedicle or funis (*d*). So remarkable is its condition at this period, that it strongly resembles the expansion of the germ in the seed of a plant, rather than the evolution of a living animal. The embryo is perfectly motionless, and the bursting of its shell appears to be effected, not by any direct effort of its own, since, up to this period, it has acquired only the form and external semblance of a living animal; but by the force of expansion of the growing body, the development of which being greatest along the dorsal, or larger curvature, exerts, in consequence, a greater degree of force against the middle of the dorsal than the corresponding part of the ventral surface; the head and tail of the embryo acting as a fulcrum against the ventral surface only at the ends of the shell, and thus bending it to the kidney-shaped form it assumes, while the dorsal surface of the embryo is gradually pressed through the opening. From the comparative rapidity of its enlargement immediately after the shell is fissured, it seems as if the stimulus given to it by exposure to a new medium, atmospheric air, is the great means of exciting its evolution. The embryo is now formed of eight distinct segments (fig. 5. *a*), including the head, the ninth or anal segment being still indistinct. The head is more defined in its outline, and firmer in texture than other parts of the body, and is inflected against the under surface of the prothorax (2.), or second segment, from which it is divided on the upper part by a deep transverse line. At its sides it exhibits a faint trace of the future antennæ. The four thoracic segments also exhibit on their ventral surface little nipple-shaped extensions, three of which, on each side, are the rudiments of the future legs. When viewed from above, the body of the embryo appears compressed and wedge-shaped, its greatest diameter being in the second and third segments, while each succeeding segment is more and more contracted. I was unable at this period to detect any separate internal organs, the whole embryo being still a congeries of vesicles or cells, in the midst of which there seemed to be some faint traces of the commencement of an alimentary canal.

It has already been stated, that certain markings exist on the egg at the time it is deposited. These are all on the external surface of the shell. They are seen, in the empty shell (fig. 5. *b*), to arise from some deficiency in the several layers of which it is formed. Some of these markings (*c c*) show that the shell is composed of at least four concentric layers or coverings, the deficiency in which, when viewed on the outside of the egg, presents an appearance which at first may readily be mistaken for the germinal vesicle and spot, seen through the shell. Each layer of the shell appears to be thicker the nearer it is to the surface. On the inner surface of the shell there is also often a slight marking (*d*), at that part which has not been separated, but forms a valve or connexion between the two halves. From the circumstance of its being near the part where the funis joins the external membrane (5. *a*. *e*) that lines the shell, and is ruptured with it, there is some reason to believe that this may have been the situation of the germinal vesicle at the period of impregnation. The fissure in the shell, although always in its longitudinal axis, is often rough and uneven, and never entirely separates the two halves.

At the *end of the first day* (fig. 5. *a*) I carefully removed the embryo and shell into diluted spirits of wine, and on examination beneath the microscope, found the body of the embryo covered with an exceedingly delicate cuticle, through which the cells it is formed of were distinctly visible. It was also completely inclosed in a smooth and perfectly transparent membrane (*c*), which seemed to contain a clear fluid, interposed between it and the embryo. This membrane I regard as the analogue of the *amnion*, the *vitelline*, or investing membrane of the embryo in the higher animals, and identical with the *membrana vitelli*, before described as the proper membrane of the yelk in the egg of Iulus. It is a shut sac, that completely invests the embryo, except at its funnel-shaped prolongation at the extremity of the body (*d*), where it is constricted, and, together with another membrane (*e*), which in the unburst egg is external to this, and lines the interior of the shell, assists to form the cord or proper funis (*d*). The *funis* enters the body of the embryo at the posterior part of the dorsal surface of the future penultimate segment, where the *mucro* or spine exists, in the adult animal, and not at the dorsal surface of the thoracic region, as seen by RATHKE in the Crustacea. The proper anal or terminal segment (9) is as yet but imperfectly developed. In the funis (*d*) I also observed some exceedingly delicate structures that exhibited all the appearance of vessels. They seemed to enter the body by two sets, that were spread over, and entirely lost in the membrane (*e*). Whether these were, indeed, vessels, or merely folds of the membrane, I am not certain. The membrane (*e*) in which they appeared adheres closely to the shell, and retains the embryo in connexion with it by means of the funis. In the unburst egg this is also a shut sac, like the amnion, and forms the *membrana externa* or *chorion* [?], the second or outer investing membrane of the ovum lining the interior of the shell.

The detection of these two investing membranes of the embryo in Myriapoda may be regarded with some interest in reference to the analogies which they bear to similar structures in Vertebrata, since they show the persistence of one universal law in the mode of development of the germ.

On the *second day* after the bursting of the egg, the segments of the body were more distinctly marked, and the form of the second, the prothoracic segment, was slightly altered, and the rudiments of the legs were enlarged.

On the *third day* the embryo had considerably increased in size (fig. 6.), but was still perfectly motionless, and attached to the shell by the funis. This attachment continues for many days, during which the embryo remains partially protected by the two halves of the shell (fig. 5 and 8.), and in so far as it has ceased to derive nourishment from an internal source, although still an embryo, it may perhaps, physiologically considered, be regarded as placed in the same relative state of extra-uterine existence, as the fœtus of the Kangaroo in the marsupium of its parent. When examined at this period in the recent state, all the parts of the body are still indistinct; but in specimens that have been for some time in spirits of wine, the divisions between the segments are well marked, and the altered form of the prothoracic segment, with its smooth rounded inferior surface, is well defined. The rudiments of the legs are more developed, but those of the second and third segments less than the fifth; so that not only at the bursting of its shell, as first noticed by SAVI, but also for several days afterwards, the embryo is completely apodal, the future limbs existing only in a rudimentary state. Posteriorly to the fifth segment, the body is more soft and delicate, and the segments less clearly defined. This results from the circumstance that it is at this part of the body that the future new segments are to be produced.

On the *fourth day* (fig. 7.) I first observed some faint traces of a single eye, or ocellus, on each side of the head. The embryo had now further increased in size, and the rudiments of its future legs had become larger and more obtuse (6. *a*); an appearance which the newly-formed limbs of the Articulata often exhibit previously to their further elongation. Traces of the formation of internal organs were now evident through the tegument at the posterior part of the body, and the funis (*d*) was contracted, as if about to separate. Internally, the body was still formed of cells aggregated together, but differing more in size than at any previous period, as if they were becoming fused into separate tissues; and in the midst of them, and closely surrounded on all sides, was the newly-formed alimentary canal. The canal was now more opake, and when pressed out of the body, more firmly adhered together, than any other internal structure, and was distinctly composed of an aggregation of very minute cells. Around the sides of the body, muscular structure was also in the course of development, but as yet was exceedingly indistinct. I could observe no perfect fibre. This fact will sufficiently account for the entire absence of spontaneous motion in the embryo up to this period. A new process was now about to commence,—the development of new segments. We have seen that on the third day the posterior part of the body is less distinctly divided into segments than the anterior, the first five segments being most distinctly marked. The sixth and seventh are now more defined. It is in the membrane (*f*), that connects the seventh with the eighth segment, at the posterior margin of which the funis (*d*) enters, and which segment is permanent as the *penultimate* throughout the life of the animal, that the formation of new segments is taking place. At this period, it is only a little ill-defined space that unites the seventh and eighth segments into one mass; but in proportion as the anterior parts of the body become developed, this part is also enlarged, not as a single structure, but as a multiplication or repetition of separate similar structures.

On the *ninth day* (fig. 8.) the changes have advanced much further. Not only have the future new segments become more distinct (*f*), but transverse depressions are also seen on the dorsal surface of the original segments, showing their division into double ones, as in the perfect animal. The rudiments of the legs are now further developed (6. *a*), and their transparent distal extremities are seen through the investing membrane applied closely together, and extended along the ventral surface of the body, as in the nymphs or pupæ of true insects. The antennæ and ocelli are more apparent, and the embryo itself has increased at least one-third of its original dimensions. It is still attached by the funis to the shell; but this attachment is daily becoming more fragile, and is now separated by very slight causes. The embryo has thus continued to grow through nine succeeding days, since the bursting of its shell, without any visible means of nourishment, the nutriment supplied by the yelk having been exhausted before that occurrence. Hence it becomes matter of inquiry, from whence it now derives its means of growth? Whether it has already sufficient materials derived from the egg, and stored up within itself for its further development; or whether the external inclosing membrane may not still contribute to the function of nutrition by absorbing fluid condensed from the air of the humid locality in which it resides? The probability of this last supposition is somewhat countenanced by the fact, that I have constantly observed the membranes of the embryo at this period covered with microscopic drops of fluid; but whether this is fluid condensed on the membranes from the atmosphere of the dwelling, or whether it results from the transudation of that which was contained in the amnion, remains for future inquiry.

Up to this period the embryo gives not the slightest evidence of spontaneous or voluntary motion. Internally, it is still composed of cells of different sizes, that are now in the course of producing muscular and other structures. In some parts of its body no arrangement of them seems as yet to have taken place, the cells being merely aggregated together. Cells of three very distinct sizes now exist. The diameter of the largest of these is nearly three times that of the second size; and the second again are nearly twice and a half the size of the smallest. The smallest-sized cells fill up the interspaces of the others, and appear as if breaking down to form interstitial or cellular substance, while the second-sized cells are arranged in rows to form particular structures. In the midst of these cells the *alimentary canal* is now nearly complete, but I have been unable to observe its connexion with the funis; and at its anal extremity it is a little dilated, and extends forward as a short straight intestine, the *rectum*, until it arrives at a part where a valve seems about to be formed. The diameter of the canal is there enlarged, and on its surface are three distinct longitudinal muscular bands. The so-called *hepatic vessels* also exist as distinct tubes, inserted, one on each side, into the alimentary canal at the constricted or valve-like part above noticed. The canal is then continued forwards until it is again dilated into the proper stomach, and terminates, or rather commences, in a narrow œsophagus. It is much longer than the body of the embryo, being convoluted or folded upon itself, in its lower portion, to adapt it to the changes the body undergoes in the enlargement and elongation of its segments. It is not yet separated from the now forming structures by any distinct investment, either adipose or peritoneal, except only what belongs to itself; but it is closely surrounded by cells of the second and third size.

On the *tenth day*, the great circulatory, or dorsal vessel, was most distinctly seen through the amnion and skin. This doubtless had existed much earlier, although not observed. It was exceedingly well marked, but I was unable to observe any motion in it. The head of the embryo had now begun to assume the peculiar corneous appearance common to the larvæ of true insects; its body had much increased in size, and the amnion was still covered with microscopic drops of fluid.

On the *eleventh day* the head was more distinct, and the antennæ appeared at its sides like short crescent-shaped clubs, with their terminations directed forwards. Above them the single ocelli were distinctly seen. All the segments, posteriorly to the third, exhibited the transverse line that indicated the division into double segments, and the posterior segments were much increased in size.

On the *sixteenth day* none of the embryos had left the egg-shell, nor exhibited any signs of motion. I now thought I could perceive some irregular movements in the dorsal vessel through the skin and amnion. The whole body of the animal was greatly enlarged, particularly in the posterior region, and more especially in that part in which the new segments were making their appearance. The head had acquired a slightly brownish colour, and the future eyes were more visible, being also slightly tinged. The first period after the bursting of the shell was now soon to close, as the amnion was greatly distended, and in a few of the specimens the funis was ruptured. In the whole of them it had become so fragile as to be separated by the slightest motion.

On the morning of the *seventeenth day* (fig. 9.) all the embryos were ready to leave the amnion. Some of them were already detached from the shell, others were still connected to it. Their increase of bulk within the last few hours had been very great. The body was now more straightened, the head less inflected under the thorax, and the eye was a dark-coloured spot above and behind the antenna. The segments of the body were divided by distinct reduplicatures of the proper tegument, and the legs, folded side by side against the ventral surface, were much further extended beneath the amnion (6. *a*). The transverse divisions of the first six segments strongly marked the original segments; and the amnion (*c*), now ready to burst, was tightly extended over the dorsal surface, and by the elongation of the body was rendered more distinct on the ventral. The great increase in the length of the animal was mainly occasioned by the growth of the posterior segments, more especially those in the ante-penultimate space,—the proper *germinal space* or *membrane* (*f*),—the faint divisions of which into new segments were now distinctly seen through the amnion. The seven anterior segments, including the head, were greatly enlarged, and the hitherto minute anal and penultimate segments (8. 9.),—in the first of which the remains of the funis (*d*) forms a rudimentary anal spine,—had also been enlarged, and were now fast acquiring the form they afterwards retain throughout the life of the animal. Some of the specimens soon threw off their covering, and entered the *third period of development.*

The animal was now greatly enlarged, and possessed three pairs of legs, but it still lay with these newly developed limbs coiled up without voluntary motion. The amnion had been fissured at its anterior dorsal surface, and slipped off backwards from the posterior segments, and lay at the anal extremity, while the animal itself with its limbs coiled up appeared as if exhausted with these, its first, spontaneous efforts. No other signs of animal existence were given than occasional slight movements of the antennæ. A second, a third, and then a fourth specimen gradually escaped from their coverings, and these were followed by others in quick succession; but so feeble at first were their efforts, after throwing off the envelope, that scarcely any motion could be perceived in them. The embryos thus passed from their apparently inanimate to an animated state of existence; from a condition in which they seemed merely to vegetate, endowed with no voluntary or instinctive powers, but, like the vegetable, formed entirely of an aggregation of cells, totally incapable of spontaneous motion, —to one in which they became active beings, gradually acquiring voluntary and instinctive faculties, both as regards the means of procuring nourishment and of preserving themselves from injury. Short indeed is the transition from a mass of uniform and inanimate cells, to the development into an active being, endowed with its peculiar instincts.

In less than ten hours from the commencement of this last change, the whole of the embryos had burst and thrown off the amnion. Those in which the funis had not been separated, now left their covering still connected by it to the shell.

In *about an hour* after leaving the amnion (fig. 10.), the young Iulus exhibited a marked change. Its head was elongated on the prothorax (2.), the parts of the mouth were distinctly moveable, and the eye, a single ocellus on each side of the head, acquired a darker colour. Each antenna was composed of six distinct joints, of which the third was much the longest, and the two apical ones were short, and sunk one within the other. The whole body had been increased at least one-fourth in bulk since leaving the amnion. It now measured about a line in length, and exhibited very distinctly the nine original segments. The seven anterior of these were strongly marked. In the *germinal space* (7.*f*), between the original seventh and eighth segments, *six new segments* were now developed. These were still very small, the length of the whole being equal only to that of one of the original segments. At the present time they did not form independent divisions of the body, but were covered by the common tegument, and thus appeared like supplementary parts of the seventh segment, produced from the germinal membrane, and interposed between the seventh and the penultimate segment (8.), which, as before stated, is a permanent segment throughout the life of the animal. This latter fact shows that it is not merely by an elongation and division of the terminal segment that the body of the Iulus is developed, but that it arrives at its perfect state by an actual production of entirely new segments; that these are new growths or formations which are in progress long before they are apparent to the eye; and that the original segments of the ovum, into which the animal is first moulded, are permanent segments throughout its whole life. But still more curious is it, that not only have new segments been formed as described, but that the common tegument by which they are now covered, and which also invests the whole body as the true skin, has already begun to be detached, preparatory to its being thrown off, as is shown in the fact that the new segments are now seen beneath it; and it is further remarkable, that this deciduation of the first skin of the animal had actually commenced before the bursting of the amnion. These circumstances explain the cause of the very quiescent state of the young Iulus, and its almost, and perhaps entire abstinence from food while this skin remains on its body. It is not until this skin is thrown off that the new segments become elongated, and the Iulus then appears suddenly to have acquired six new divisions to its body. The production of new legs is equally curious. Up to the present period the animal has but six legs (6. *a*). But four additional pairs are nevertheless in the course of formation. These at present exist only as eight minute nipple-shaped prominences on the under surface of the sixth and seventh segments (*b*, *c*), four on each, covered by the common tegument, which we have seen is becoming deciduous. The three single pairs of legs that now exist as the only locomotive organs, are attached, one pair to the prothoracic or second segment, one to the third, and one to the fifth segment. The fourth, or segment intermediate between these, never possesses any legs, but in the female contains the outlets of the organs of generation. In pursuing the analogies between these segments and the thorax of insects, the first two seem to represent the *pro-* and *mesothorax*, while the fourth and fifth becoming united, answer to the *metathorax*: this is analogous to the fusion of the fourth and fifth segments in the changes of true insects. The general appearance of the animal has now become less delicate, the head has acquired a darker colour, and a faint broad brown patch (*p*) is now making its appearance at the anterior part of the seventh segment. This patch, which is permanent through all the earlier changes of the animal, is of the greatest utility in determining the production of the new segments. It is in the segment immediately posterior to this that the male organs find their outlet, a circumstance the more remarkable, from the fact that this outlet is in the anterior part of the original germinal space, and that at the bursting of the egg this is very near the termination of the body. This was the condition of the young Iulus *one hour* (fig. 10.) after leaving the amnion. It soon began to exhibit its animal powers, to show the instinct peculiar to its species, and to be sensibly affected by external causes. In less than six hours from the bursting of the amnion, those specimens which had first undergone the changes were in motion. At first the antennæ were the organs employed. They were moved slowly to and fro, and seemed to gain power by use; in a short time the limbs began to be extended, and the animal slowly raised itself upon them for the first time. Its first efforts at locomotion were exceedingly feeble, but it gradually gained strength. At the end of twelve hours the whole of the embryos were in motion, crawling about slowly, but moving the antennæ briskly. On exposing them to a strong light, a marked effect was produced in their movements. They evidently were greatly affected by it, and seemed instinctively to shun it, retiring out of the way. This was the first marked exhibition of instinct. Locomotion was at first performed very slowly, but with instinctive care. The anal segment previously to each step was expanded like the anal leg of the larva of an insect, and being first attached like a true proleg, and its step, as it were, measured, its body was carried forwards by an effort that extended, as in insects, from segment to segment.

At *twenty-four hours* (fig. 11.) after escaping from the amnion, the young animals were lying together in a heap, but when disturbed, seemed to have acquired more power of moving; they remained quiet except when aroused, and had not yet taken food. The only marked difference in their appearance, excepting that they had still further increased in size, was in the nipple-shaped protuberances on the sixth and seventh segments, the rudiments of future legs (*b*, *c*). These were now more distinct and mammiform. Ten hours later in the day, they assumed still more the appearance of nipples projecting from the under surface of the segments. When examined in specimens that had been placed in spirit of wine, it became evident that these projections were occasioned by the development under the deciduous tegument of four new but exceedingly minute legs, complete in all their parts, each covered by its proper skin. The claws to the legs of the other segments were also more strongly marked. The new segments (7.*f*) were now more developed, although still covered by the common tegument, and, as in the preceding state, forming only one division of the body, while a small space behind them (*g*) indicated the point from which other new segments were to be produced.

On the *nineteenth day* (fig. 12.) these animals had acquired a little darker colour, but were still remaining quiet in their cells, and did not appear to have taken food. The enlargement of the body had not extended to the prothorax, which did not increase in size in proportion to the rest. The eye was more distinct, and the margins of the segments were bordered with short red points. The double pairs of new legs to the sixth and seventh segments, were now distinctly visible through the external tegument, which had begun to be separated from the under surface of the old segments, to which, up to this period, it had closely adhered. The patch on the side of the seventh segment had become darker, and the new segments were further advanced.

On the *twentieth day* (fig. 13.), although the animal continued almost motionless, it had acquired much strength; its limbs were much larger, and the claws at their apex more distinct. In a specimen that had been hardened in spirit of wine, the rudiments of the two double pairs of legs of the sixth and seventh segments (*b*, *c*), each encased in its own proper skin, were seen coiled up, with all the articulations perfect, while still further enlargement had taken place in the new segments. The common tegument was extended over the new segments, as in the previous observations, and the animals were still collected together among the burst envelopes of the eggs, and the cast-off amnions, remaining, as it were, in a kind of pupa state.

On the *twenty-first day* (fig. 14.) they were in the same condition, coiled up, perfectly quiescent, with their legs disposed side by side along the under surface of the body, like the pupæ of Lepidoptera. The new legs had now considerably increased in size, as well as the whole animal, although it had not taken food. The animal was still partially coiled up, but the skin that covered its body was greatly distended, more especially along the ventral surface. It was less able to move than before, the period of throwing off this skin being fast approaching; the double legs of the sixth and seventh segments, inclosed in their proper skin, were now more elongated, and very much enlarged, and the new segments were further developed, as well as the future germinal membrane (*g*). The external tegument was more extensively separated from the whole body, especially at the posterior part, and the head was retracted within it, and bent on the under part of the thorax. It was thus evident that this tegument was not of recent formation, that it simply inclosed the animal, as the whole had previously been inclosed in the amnion, as is proved by the circumstance that it extended smoothly over the whole body, antennæ and legs, and did not follow the inflexion or reduplication of the proper surface of the animal like the folds of the true skin beneath it, as in the original segments (14. 7.), but passed directly over them, and was simply protruded or extended by the growth of parts beneath, as in the instance of the new legs (*b*, *c*). Up to this period the young Iulus must still be regarded as in the embryo condition, although for a day or two after bursting the amnion, it possessed the power of locomotion, and evinced some development of its peculiar instinct. At its next change of skin, when it enters what I regard as the fourth period of its development, and when it has acquired fourteen pairs of legs, it assumes for the first time a condition analogous to the larva state of true insects on bursting from the ovum; the difference between the two being, that the analogue of this tegument of the embryo in insects is slipped off at the bursting of the amnion on leaving the shell, while that of the Myriapod is not thrown off until some days after it has entirely left the ovum. The correctness of this analogy is confirmed by the fact, that the double legs, which may be regarded as the analogues of the abdominal legs of the Caterpillar, are not acquired until a late period in the development of the embryo in insects, as I have seen in the embryo of the Caterpillar of one of the Saw-flies, *Athalia centifoliæ*, in which the first legs developed are the thoracic, and at a little later period, while the larva is yet in the egg, the abdominal ones. The permanent state of Iulus is thus strictly analogous to the transitory condition of the insect in the larva state, the relative development of the two being very similar. The Iulidæ and other Myriapoda are thus connected, on the one hand, with insects in the larva state; and, on the other, still more closely with the Annelides by the reproduction of segments of the body; the repetition of the segments in Iulus and other Myriapoda being one of the last occurrences in the higher forms of Articulata, in which distinct segments, or principal, and vital portions of the body are formed after leaving the ovum. This phenomenon almost entirely ceases in the higher families of Myriapoda, the Scolopendradæ, in which the number of segments produced is gradually diminished. I may here also remark, in proof of the persistence of the same principles in the development of the egg in true insects, that in *Athalia centifoliæ* I have found the animal in its shell inclosed in a distinct amnion, and that the funis enters the body of the embryo at a part precisely similar to that of the entrance of the funis in Iulus, the posterior margin of the penultimate segment, the prolongation of which segment in some larvæ of insects, the *Sphingidæ**, &c., may be regarded, as in the Iulus, as the remnant and representative of the funis.

This embryo condition of the animal will thus explain the circumstance of its first acquiring a slight power of locomotion, and then remaining perfectly quiescent, without taking food, to prepare for this change,—the third period of its embryo life. It is then to prepare for this last change that it now lies perfectly quiet, absolute rest being necessary to its proper evolution, which may probably be retarded by the slightest disturbance.

The lower portion of the alimentary canal is now distinctly visible through the new segments. When examined by transmitted light, it exhibits a corrugated or folded appearance, being folded to allow of its sudden extension at the period of throwing off the skin, and elongation of the segments. The colon is of a very dark colour, and exhibits its thickened peculiar structure, with its longitudinal muscular bands. Around its posterior part I observed an aggregation of what appeared to be globular cells. They seemed to be part of the organs of generation in the course of development. At first I regarded them as hepatic vessels, but this could hardly be the case, from the fact that each of these organs directly enters the canal as a straight vessel; but they might be vessels folded up to be unfolded suddenly, as in the case of the alimentary canal.

On the *twenty-second day* (fig. 15.) but little further advance is made in the development of the animal, save only that the original segments more distinctly exhibit the appearance of the segments of the perfect Myriapod. This appearance was more distinct than on the previous day, and consisted of transverse markings that divided each segment into two parts, the posterior of which was now impressed with longitudinal striæ. From the length of the posterior portion of each segment being slightly shorter than the anterior, it is evident that the segments had not yet acquired their fullest development, although they were more advanced than on the previous day. The dark patch of colour on the sides of the seventh segment, which first began to show itself on the seventeenth day, was now much more distinct, and became each day more and more apparent. The head of the animal was a little more bent on the thorax; the limbs more straightened; the new segments much further developed; and the whole indicated that the deciduation of the covering was now rapidly approaching.

The *fourth period of development* is as distinctly marked as the third. The young Iulus now has seven pairs of legs, and fifteen segments to its body.

On the *twenty-sixth day* (fig. 16.) nearly the whole of my specimens had changed their condition. In the morning some of them had already undergone the change, and were now briskly moving their antennæ, but still remained collected together. The antennæ were elongated at least one-third of their original length, and exhibited six distinct joints. The eye still consisted of a single ocellus, but this was now surrounded by a darker coloured portion of the tegument. The new legs (*b, c*) were

* Philosophical Transactions, 1834, Part II. Plate XIV. figs. 11 and 12. (12.)

equal in size and length to the original ones, but were evidently more feeble. The transverse markings on the seven anterior segments (2. 7.) were very distinct, and the large brown patch (*p*) on the seventh segment was much darker in colour. The whole body of the animal was considerably elongated. This was produced chiefly by the extension of the new segments (7. *f*) formed from the germinal membrane at the posterior part of the seventh, and which, in the early part of the last period, seemed to form a single distinct segment covered by the common tegument. The most anterior of these new segments (8.), now the eighth of the whole body, had acquired an extent equal on its upper surface to the preceding segment, but was shorter on its ventral surface. Like the preceding original segments, it was divided into two regions by a transverse depressed line. The next segment in succession to this, the ninth, had also become enlarged to about one-third of the eighth, and was like it marked transversely. The next four segments were each more developed than in the preceding state, but not to so great an extent as the others. The two remaining segments (14. 15.), the penultimate and anal, had undergone no change. They had simply acquired a little extension at the apex of the segment, and were now covered with a few scattered hairs. It is thus proved that the body is elongated, not by the division of already formed segments into others, but always by the formation of new ones in the germinal membrane that extends from the posterior margin of the antepenultimate segment, to the penultimate, which last segment, with the anal, undergoes no change. That segment is always furthest advanced which is immediately posterior to the last segment that possesses legs; and then the next in succession, until we arrive at the terminal ones, the penultimate and anal, which never bear legs. The body of the Iulus is thus formed of fifteen segments. In this respect it affords a further analogy to those already pointed out with the larva of insects at their first coming from the egg, only that the Iulus is one grade lower. The usual number of segments in insects is thirteen, but this is not constant. It varies in accordance with the higher or lower state of development of the species. Thus, in some, the thirteenth is only a very rudimental one, even less developed than the fifteenth at this period in Iulus. But in some of the apodal larvæ, which approach closely in their rudimental condition of development to Iulus, the number is fourteen, besides a minute anal tubercle, analogous to the anal or fifteenth of Iulus. This has already been elsewhere shown both by WESTWOOD* and myself†, and seems to confirm the view here advanced with regard to the comparative development of these animals; though in Iulus all the segments are double.

On the *twenty-eighth day* I found all the specimens, now in the fourth period of development, still lying collected together. On moistening the soil in which they were placed, they soon moved briskly their antennæ, as if seeking nourishment; their motions were still exceedingly feeble. This could not have arisen from too reduced

* Transactions of the Entomological Society, vol. ii. p. 124.

† Cyclopædia of Anatomy and Physiology. Insecta, vol. ii. p. 871.

a temperature of the surrounding medium, as the last few days had been exceedingly warm, and at the time of making this observation the temperature of the atmosphere was 73° Fahr., and was not lower than 72° Fahr. during the whole day. I am greatly inclined to think that the elevated temperature of this and the following day, very much accelerated the subsequent changes in some of the specimens.

On the *twenty-ninth day* (fig. 17.) the temperature ranged between 67° and 70° Fahr. The young Iulidæ were now moving about very briskly, with their antennæ in constant motion. They now partook very freely of food, which consisted of the nutritious matter found by them in the moistened clay in which they were placed. Many of them had completely gorged themselves with it, as was evident from the darkened and distended state of the alimentary canal and colon, which were distinctly seen through the teguments of the body. The warmth and moisture at this period seems to have been extremely beneficial to them. Some of them appeared already to have acquired their peculiar instinct of burrowing in the clay, as several were very busily at work in a little round hole at the bottom of the cell: their bodies seemed also to have acquired a degree of strength sufficient for this purpose. The external tegument had become of a much darker colour, and assumed the appearance of horn. The divisions of all the segments were very distinct. The limbs had acquired much strength, and the anal segment was expanded and employed, as before stated, like the anal proleg of the larva of Coleoptera. The six new segments had grown very much and were fast acquiring their full size, and the germinal membrane at the margin of the antepenultimate (13. *g*) filling the *germinal space*, was beginning again to be developed. The large patch on the seventh segment was now deeper in colour, and in a line with this there was a minute spot on each of the five succeeding segments, indicating the existence of the *foramina repugnatoria* (8 to 12.) of Waga, or entrance to the little sacs in the body that secrete an offensive fluid. The first of these sacs is situated in the seventh segment, its outlet being in the large patch just noticed; and one of them is also developed at the anterior part of each of the succeeding segments, to the twelfth inclusive; but none is as yet seen in the thirteenth or last of the new segments, which may be called the *germinal segment*, and not only at the present time, but in each of the succeeding periods, always is more delicate than the others, is shorter, and has no repugnatory foramen. The terminal segments are still covered with short scattered hairs. The eye now exhibits a peculiar appearance. The dark circle around it has changed its form, and become somewhat triangular, and the single ocellus in the centre seems as if formed of several eyes grouped together.

On the *thirtieth day* I removed the specimens into a new habitation, a small phial, the bottom of which was filled with mould, and the top secured by a cork. On putting some macerated boiled meat, or animal fibre, into the bottle, they fed most voraciously upon it. They had now acquired much strength, and were of a much darker brownish colour. The alimentary canal was still seen through the teguments, filled with food. The new segments were still soft and delicate, and the anal segments were still employed in locomotion, as above stated. The germinal space now showed indications of the formation of other new segments. Each of the new segments had been much increased in size, from the eighth to the thirteenth inclusive; those most anterior being the most perfect. The fourteenth, or penultimate segment, as before shown, still maintained a great superiority over the rest in point of size and colour, although the whole had become darker, and were thus more clearly distinguished from the thirteenth or ante-penultimate, and germinal space, which are always whitish and delicate. The annulus around the ocellus was now of a more triangular form. There were a few scattered hairs on the anal segment and the under part of the body, as well as on the antennæ and parts of the mouth. The temperature of the atmosphere was about 70° FAHR.

On the *thirty-first day* (fig. 18.) the new segments had acquired a darker colour, and become further developed, and were almost equal in size to the original ones; but the thirteenth, and the germinal space, were still whitish and delicate. No additional legs had yet been developed, but there seemed to be a little distention of the under surface of the eighth segment in some of the largest and most active specimens, and in the whole of them a slight alteration of position had taken place in the six true legs. The prothoracic legs (2.), approximated at their base, were situated more closely to the anterior of the mesothoracic segment (3.), while those of the latter, in like manner, approached the generative or fourth segment; and those of the fifth segment, which I regard as the proper metathorax, had advanced a little forwards to the fourth. In other respects the animal remained the same as on the previous day.

On the *thirty-third day* (fig. 19.) it was evident that the high temperature of the atmosphere had accelerated the changes which in some of them seemed about to take place. The temperature of the atmosphere was now 67° FAHR. One specimen, that had undergone its change a few hours before, now exhibited two additional pairs of legs to the eighth segment (8. 18.), which on the previous days was enlarged on the under surface; several specimens at this period underwent a change, but I am not certain whether they actually shed their skins, or whether the legs were simply developed from the eighth segment by the extension of the old skin, as I did not actually witness the supposed exuviation of this covering. In other respects these individuals seemed to remain in the same condition as those specimens that had not cast their tegument, saving that the body was a little more extended, and the germinal space (13. *g*) was more developed. I cannot help regarding this change, therefore, as a *pseudo-change*, which takes place only under certain circumstances, such as repletion with food and moisture, and high temperature of the surrounding medium, operating, perhaps, on those specimens which were furthest advanced and first developed from the egg; since there are strong reasons for believing that those which are developed earliest from the egg undergo their changes most rapidly, while those last developed are later than the others at each succeeding change, so that some specimens may be entering their fifth period when others have not yet passed their fourth. This I have no doubt was the case with these Iulidæ, some of which acquired their two additional pairs of legs on the thirty-first day, others on the thirty-second, and some not until the thirty-fifth, and thirty-sixth and seventh; while the remainder did not undergo this change at all, but continued to feed and remain active, and instead of now acquiring two pairs of legs, acquired ten pairs at their next change, or fifth period of development.

On the *forty-fifth day* (fig. 20.) the whole of the remaining specimens were preparing to undergo their transformation. This appears to have been their proper period of change. The variation in the shedding of the skin just noticed, includes, from the time when the first specimen changed, to the completion of that process by the last, a period of six days. The specimens had now acquired a much darker colour, and the marking on the seventh segment was becoming paler. This was one day before the change. The temperature of the room was now 65° FAHR. What renders it more probable that the preceding was a pseudo-change, is, that I was unable to rear any of the specimens which underwent it, while others that attempted to change a little subsequently to those at the period noticed, perished in the attempt. The proper period was now approaching. On the forty-fourth day the specimens had ceased to take food, seemed torpid, and lay coiled up in a spiral form; the tegument of the body now began to assume a whitish crustaceous appearance, and the animals secreted themselves beneath any dry covering, but avoided parts too wet. The principal changes in their general appearance were in the eyes, each ocellus being much more distinct; and in the germinal space (*g*), which was now developed to its greatest extent, and distinctly exhibited the six new segments.

The casting off the skin, as in insects, is a tedious and eventful occurrence to the young Iulus. WAGA states that the skin of the Iulus bursts on the under surface of the body in the thoracic region, *between the single pairs of legs*; that the head is first withdrawn, and afterwards the anterior segments, and then the rest of the body. I have been unable to confirm his account as to the part at which the skin is fissured. According to my own observations, when the young Iulus is about to change its skin, it bends its body in a semicircular form, with its head inflected against the under surface of the second segment. In this condition it remains for several hours, with its legs widely separated, and the dorsal surface of the segments extended. The head is then more forcibly bent on the sternum, and a longitudinal fissure takes place in the middle of the epicranium, and is immediately extended outwards on each side posteriorly to the antennæ, in the course of other sutures, the analogues of which I have elsewhere described in insects as the *triangular* and *epicranial sutures.* Through the opening thus formed in its covering the head is first carefully withdrawn, and with it the antennæ and part of the mouth, and afterwards the anterior segments and single pairs of legs. The first, and apparently the most difficult part of the shedding of the skin by *Iulus,* is its detachment from the posterior segments of the body, and from the interior of the colon. To effect this, the animal, which has previously been lying coiled up in a circular form, first straightens its whole body; it then forcibly contracts and shortens its body, especially at the posterior part, and by this means becomes greatly enlarged in bulk at its middle portion, but smaller at its extremities. During these efforts, which are some of the most powerful it is able to make, the skin becomes loosened from its posterior parts, and while still contracting its segments, the anal extremity, and with it the lining of the colon, become entirely detached, and from these it gently withdraws itself within the old skin in which the body is incased, as from the finger of a glove. This is precisely what takes place in the shifting of the skin in insects. Having effected this part of its labour, all the posterior segments are again shortened, the animal again disposes itself in a circular form, and after repeated exertions succeeds in bursting the tegument of the head in the part just described. As in the case of true insects, the young Iulus entirely empties the alimentary canal by voiding its fæces, and ceasing to eat for one or two days preparatory to undergoing each transformation. When examined immediately before the change, there are no other symptoms of new legs than slight elevations of the skin, and this perhaps accounts for the length of time occupied in the change, the new legs requiring time for further development before the old skin is thrown off.

When these changes have been effected, the animal again arranges its legs along the ventral surface of the body, and coils itself up in a circular form, in which state it remains for several hours, often with the skin partially covering the posterior segments. In these transformations, as in those of insects, the whole of the structures undergo alteration; the lining membrane of the colon and lower intestines comes away attached to the posterior, as that of the mouth and œsophagus does to the anterior part. It is not, therefore, by the bursting of the skin on the under surface of the anterior segments that the change is effected, as stated by WAGA, but by a separation of the natural sutures of the covering of the head. Indeed it is almost impossible to conceive how the legs of the thorax and covering of the mandibles could be thrown off if the change took place as stated by WAGA.

It has been supposed that the Iulus devours its cast skin, as is done by some larvæ of insects. I certainly have seen it nibbling at the skin some hours after the change, but although there were several cast skins in the vessel, and no food, there seemed no disposition on the part of the animal to devour it.

The *fifth period of development* being now attained, the young Iulus has three ocelli on each side of the head, seven joints to the antennæ, thirty-four legs, and twenty-one segments to its body.

On the *forty-eighth day* (fig. 21.) the young Iulus has entered this period, and exhibits a marked alteration in its appearance. The antennæ are considerably longer than the head, with seven distinct joints, and, as in the adult, the apical one is short and inserted into the sixth. The length of these organs has been increased chiefly by the elongation of the second basilar joint, which is now narrower and longer than the others. The single ocellus has disappeared, and in its stead three distinct ocelli, arranged in a triangle, have been developed. The apex of the triangle is directed upwards. The ocelli are of two sizes, the largest, a single one, being at the posterior angle. The development of an increased number of ocelli in Iulus at successive periods was discovered by M. Gervais, but the precise time of their appearance has not before been indicated. The new segments of the body produced at the former change of the animal, from the eighth to the twelfth inclusive, are now of the same size as the original ones, and each has developed from it two additional pairs of legs, so that the whole number of legs is now thirty-four. The thirteenth, or if we may so term it, *germinal* segment of the last period, is less developed than the preceding ones, and is distinguished from them by the circumstance that it is smaller, possesses no legs, and has no lateral spot, which exists, as above stated, on each of the preceding segments, to the seventh, marking the existence of the *foramina repugnatoria*. The large patch on the seventh segment is now larger and darker than heretofore, and the spots on the succeeding segments have been increased in size. The *germinal space* (13.*g*), which existed in the preceding period, and was then seen to be forming segments, is now developed into six new apodal segments, from the fourteenth to the nineteenth inclusive, very much smaller and shorter than the rest; and a germinal space (*h*) is again forming between the last of these and the penultimate segment of the body, which, as above stated, undergoes no marked change. The whole body is thus composed of twenty-one segments, including the head. The first twelve of these are now perfectly developed, as well as the last two, the intermediate ones being only in their preparatory states. The antennæ, parts of the mouth, legs, and anal segments, are still covered with minute hairs. At this period I gave my specimens for food some decayed leaves and rotten bark of the elm, as also some uncooked potatoe, on which they seemed to feed voraciously. They seemed to thrive most rapidly on the decaying bark, and grew daily, especially at the posterior extremity of the body.

On the *sixty-second day* (fig. 22.) all the specimens had been lying quietly coiled up in a circle for nearly twenty-four hours, preparatory to again changing their skin. The segments, from the thirteenth to the eighteenth inclusive, which had been partially developed at the last change of skin, were now nearly completed, and exhibited the transverse impression of the perfect animal; and the future spots on the sides of these segments were now shining faintly through the old skin, which had become whitened and dried, exhibiting the peculiar appearance of the approaching change. Besides this, instead of the three ocelli developed at the last change, there were now *five*, which appeared through the tegument, still arranged in a triangle; one of these was larger than the last, and distinctly formed of two parts, so that *six ocelli* were now about to appear. The number of legs still continued the same as at the last change. The nineteenth segment, which, at the period of transformation, was but a very soft fold of the tegument, with a slight division in the middle of it attached to the eighteenth, was now almost as much developed as the preceding ones, and the white germinal membrane, extended from it, showed the formation below it of six new segments. In this state the young animal lay coiled up awaiting its change.

On the *sixty-third day* the animal again changed its skin, and entered its *sixth period of development*. It then had acquired twenty-seven segments to its body, which had greatly increased in size, and was of a brown colour. It had six distinct ocelli on each side of the head, and all the segments, to the eighteenth inclusive, were furnished with legs, of which it had now fifty-eight. Six additional new segments had also been developed to its body, as in the preceding changes, anterior to the penultimate segment; and the germinal membrane behind them (*i*) was still in further course of development, the penultimate segment still remaining unchanged. The six segments from which legs had now been developed had also the *foramina repugnatoria* marked with small spots, while the spots on the preceding six had become larger and darker in colour. The chief difference now consisted in the appearance of the thorax, which is of a lighter colour than the rest of the body. The animal may now be regarded as having acquired all the essential parts of its body. Time and circumstances prevented me from following its transformations still further; but sufficient, I trust, has already been observed to claim from naturalists a little more attention to the remarkable series of phenomena connected with its growth, and to add to the importance of watching the development of this greatly neglected, but most singular group of animals.

Recapitulation and Conclusions.

The conclusions to which the facts detailed in this paper seem to lead, are, I think, as interesting to the zoologist, in reference to the situation which this remarkable class, the Myriapoda, ought to occupy in the arrangement of animals, as to the comparative anatomist, and physiological inquirer. The evident conformity to one type of the organs of reproduction in the two sexes, is in accordance with the views now advocated by the best anatomists. It has been seen that the Iulidæ, in some parts of their organization, as in the organs of reproduction, approach in their internal structure to the true insect, in maintaining, although in a simple state, a perfect form of development; while, in the external parts of the same organs, as in the double outlets of the female, and double organs of intromission of the male, they again recede to the type of those in which these organs exist in one of the lowest forms of development.

The structure of the ovum in Iulus approximates to that of the higher classes, and is in accordance with the observations of WAGNER, BISCHOFF, and of Dr. MARTIN BARRY, whose invaluable researches on this subject have so recently enriched the Transactions of the Royal Society. The same reasons that induced this last inquirer to advocate the existence of the *membrana vitelli* and *chorion* in the earlier stages of the ovum of higher animals, have also led me to believe in its existence in these lower forms, the Myriapoda; an inference entirely in accordance with the facts subsequently ascertained respecting the membranes that invest the embryo at the bursting of the ovum.

Moreover, the few facts detailed in this paper show that the habits of these creatures, although hitherto comparatively neglected, are as interesting to the naturalist as those of the more extensively investigated divisions of other Articulata.

But it is in the evolution of the embryo that the facts ascertained appear to be of the greatest interest. In conformity with the views of SCHWANN and SCHLEIDEN, and of our own accurate observer, Dr. MARTIN BARRY, the embryo of Iulus in its earlier stages is found to be composed entirely of a congeries of cells, thus assimilating in origin the animal to the vegetable creation. But in the higher animals, as is well known, in which, chiefly, this subject has been studied, the changes which the future being undergoes in this stage of its existence are so exceedingly rapid, that it is with great difficulty that the facts connected with them are ascertained. In the embryo of the Myriapoda these changes are more gradual, and the transitions more slowly marked. Besides confirming the statements of SAVI and WAGA regarding the apodal condition of the embryo at the bursting of its shell, and its hexapodal state at a later period, I have noticed the important additional facts of the detection of the *amnion* and *chorion* [?] which inclosed the embryo, and also the insertion of the funis at the posterior margin of the penultimate segment of the body, instead of at the dorsal part of the thoracic region, as seen by RATHKE in Crustacea; thus more closely identifying the structures of the embryo, as well as those of the ovum in Myriapoda, with similar structures in the ovum, and its development in the higher classes, and further illustrating the persistence of one general law or principle in the development of animated beings.

But not less interesting is the fact, that the growth of the animal takes place by the addition of entirely new segments, developed in the germinal membrane that connects the penultimate with the *then* ante-penultimate segment. This mode of increase by the generation of new segments, and not by the extension or division of those already formed, closely connects the Myriapoda with the Annelides, and somewhat resembles the growth of segments in the fissiparous *Naïades* of the latter class, as remarked to me by my friend Dr. BALY, when examining the specimen beneath the microscope. But it differs from the reproduction in these animals, in the circumstance that the segments produced are not the terminal segments of the body, but are new formations in the germinal membrane interposed between the newly formed ante- and the permanent penultimate segment.

The development of segments is one of the first changes in the embryo, and commences even before it bursts from the amnion. It is repeated with corresponding numbers at each change of tegument. In the *Iulus terrestris,* during the earlier transformations, the addition is *sextuple* at each change, a ratio that agrees most curiously with the number of segments found in the adult state. But it is not to be inferred, from this fact, that this is the number of segments produced at each change in all the *Chilognatha,* or that the new segments are produced in a corresponding part of the body in the other divisions of this class, the *Chilopoda.* In these two orders the parts in which the new segments appear differ greatly, and most distinctly mark these two divisions of the Myriapoda. In the *Chilognatha* the segments are always produced as above stated, but in the Chilopoda, the proper Scolopendradæ, according to GERVAIS*, the new parts are developed between *each* of the original segments. These are remarkable differences in the modes of growth of the two orders of this aberrant and most singular class. Although the new segments make their appearance at the same part of the body in all the Chilognatha, they differ in number in different animals of this group, and from the few observations I have yet made, I am inclined to believe that this difference is characteristic of different genera. Thus in *Iulus terrestris* it is sextuple through the earlier periods of life, but in a well-defined genus, *Blaniulus,* nearly related to Iulus, the number of segments at each reproduction appears to be *quadruple,* while in the young of another genus, which I believe to be *Polydesmus,* closely connected with the above, the number of segments appears to be only twofold at each change. But in each of these instances the number of new segments is similar throughout the earlier changes of the animal.

The development of legs takes place subsequently to that of new segments, which, when first produced, are always apodal, the legs being developed to the new segments at the next change of tegument. But as regards the number of legs produced, this is less regular than that of the segments. Thus in the hexapodous condition of the animal, legs are being produced to only two of the original apodal segments beneath the common tegument, while six new segments are in progress beyond them. When the skin is thrown off the legs are elongated, and the segments become more developed. In the mean time new legs are being formed beneath the tegument for those new segments, while other new segments are being produced beyond the last of these organs of locomotion. In like manner the eyes make their appearance as one of the last commenced changes, while the antennæ are the parts that earliest attain their full development. Such are the conclusions at which I have arrived in these investigations, which I propose to continue at a future period.

* *Loc. cit.*