the surface of which was a little water; it was placed in the garden with a sunny aspect. Mould was introduced, and some seeds of wheat and peas. After fourteen days it was found that the peas had merely split, and were black and decomposed, while the wheat showed no signs of germination, and were quite soft and decayed. An analogous experiment was made with pure oxygen gas. Both the peas and wheat germinated and grew a little, until no doubt the atmosphere of the jar was in a great measure converted into carbonic acid, when they also decayed. It appears then that carbonic acid in considerable excess has a positively injurious effect on germination.

In concluding the record of this investigation of the influence of solar radiations on the growth of plants under different atmospheric conditions, I feel very sensible of the imperfect nature of the results, and am convinced that such are the difficulties of the inquiry, that the conclusions actually arrived at must not be generalized without the greatest caution. Yet at the same time I beg to express the hope that other observers may take up some of the questions, to which I have incidentally alluded, but which still remain unanswered.

On the British Edriophthalma. By C. Spence Bate, *F.L.S. &c.*

Part I.—The *Amphipoda.*

Introduction.—The term *Edriophthalma* has been given by Dr. Leach and recognized by all subsequent naturalists, as applied to a legion of Crustacea that differs in several of its external characters, independently of the eyes, from that on which he has conferred the antagonistic term of *Podophthalma.*

These two applications are not capable of comprehending within their separate significations every genus which it is desirable should be so embraced. There is a whole family that belongs to the Macroural type, the eyes of which are sessile, being lodged beneath the integument of the antennal segments. This infringement, which occurs in the *Diastylidæ* *, shows us that it is not necessarily a law among Crustacea that the eyes shall be borne on footstalks whenever there is a tendency to an accumulation of the nervous ganglia into a central mass, even though that centralization be more or less imperfect.

Again, the infringement is repeated upon opposite evidence, for we perceive that the eyes may be borne on footstalks where the nervous system is divided into many separate ganglia. The genus *Tanais* among *Isopoda* has the eyes raised upon distinct pedicles, which we believe are moveable, and differ from the eyes of the *Podophthalma* only in being less club-shaped.

But ever since the time of the great Swedish naturalist, Linnæus, the relative position of the eyes has been held as a means of natural classification, distinctly separating one great family of Crustaceans from that of another; and although there are exceptions which demonstrate that the arrangement is not free from error, yet so very generally is the application correct and so easily capable of discernment, that it probably will remain a permanent mode, even should a more perfect but less readily detective system of natural arrangement be discovered.

The term *Edriophthalma* was first understood to contain all the Crustacea which were not embraced within that of *Podophthalma*, and, with the exception of the *Cirripedia,* they are still so retained in Mr. Dana's classification of

* *Cuma,* &c. of M. Milne-Edwards.

Crustacea. It therefore would embrace a large number of Crustacea, which vary considerably in their habits and forms, some of them belonging to well-organized beings, whereas others degenerate in character and descend to those which assume an insect-like appearance.

The first step therefore separated the Entomostracans; and now when we speak of the *Edriophthalma*, it is understood to be a legion intermediate between *Podophthalma* and the *Entomostraca* of recent Crustacea. But this term still conveys too wide a signification. Latreille therefore divided it into two, one of which he named *Amphipoda*, the other *Isopoda*. A third subdivision was established by the same author, that of *Læmipoda* (or *Læmodipoda**). This embraces an aberrant group of *Amphipoda*, which previously were ranked among the *Isopoda*, and must be looked upon as differing from the normal type in the rudimentary character of certain parts, rather than as possessing separate qualifications of their own, warranting their being formed into an order of equal importance to the other two, although it has been retained in this position by the profound authority of Professor Milne-Edwards.

Lamarck embraced these, together with the *Amphipoda* and *Isopoda*, as in one family.

Duméril, in his 'Zoologie Analytique,' united the *Amphipoda* with the *Stomapoda*, notwithstanding the pedunculated character of the eyes of the latter, because in each of these genera the head, he thought, was "separated from the corselet." To these united tribes he gave the name of "*Arthrocephalés*" or "*Capités*."

Desmarest, in his 'Considérations générales des Crustacés,' has adopted the order of *Læmodipoda* which Leach united with the *Isopoda*, because he thought the vesicular sacs to be "spurious" legs.

M. Blainville, in classifying Crustacea, arranged these three under the term *Tetradecapoda*, as antagonistic to that of *Decapoda*, which is synonymous with *Podophthalma*. The adaptation of the name by Blainville to the sessile-eyed Crustacea, arose from the circumstance of their possession of fourteen legs, but this characteristic circumstance is not a constant fact.

It is true, that in *Caprella* the legs are obsolete, and in *Anceus* are altered in form, though present; yet if these facts be not admitted of importance in consequence of their homological signification, then we must include them with the higher orders, for the only separation which naturally exists is the modification of the forms of certain parts homologically the same. Thus it will be found that ten-legged Crustacea exist among the sessile-eyed form, which in all other respects are nearer allied to true *Isopodes*. *Anceus* and *Paniza*, though only possessing ten perambulatory legs, approximate nearer in their structural signification to the fourteen-legged Crustacea than to that class, which the number of these legs would seem to suggest.

The term *Choristopoda*, from *χωριστὸς separate*, *ποῦς foot*, has been lately applied by Mr. Dana, and is made synonymous by its author with the *Tetradecapoda* of Blainville, and includes the *Amphipoda*, *Læmodipoda*, *Isopoda* of authors, and the *Anisopoda* of Dana.

Perceiving no advantage in the new term over its older synonym, and fearing the result of multiplying names, it is the intention in this Report to adhere to the one most commonly used, and on that account most generally understood. We consider the second division of Crustacea as *Edriophthalma*, using it as synonymous with *Tetradecapoda* of Blainville and *Choristopoda* of Dana.

* At first Latreille placed the animals belonging to this order among the *Isopoda*, section *Cystibranches*.—(*Dictionnaire d'Histoire Naturelle.*)

Thus it will be perceived, that, instead of considering *Trilobita*, *Entomostraca*, and *Rotatoria* as orders belonging to the second division of Crustacea, as Dana has done, we take them to form natural divisions in themselves, with wider structural demarcations than exist between the *Macroura* of the first division and the *Amphipoda* of the second. This nearer approximates the system of arrangement adopted by Milne-Edwards in his 'Histoire des Crustacés.' But in his classification, Latreille's order of *Læmodipoda* is admitted to a rank of equal importance to that of the *Amphipoda* or *Isopoda*.

This, from a correct appreciation of the homological relation of the several parts, Mr. Dana (whom as a carcinologist no one appears to have surpassed in close observation) entirely ignores, and embraces the *Læmodipoda* within the order of true *Amphipoda*, making no allowance in his arrangement for their naturally aberrant departure in outward form from that group. "They are," says that author, "properly therefore *Amphipoda* with certain parts obsolescent. . . . The more essential characters are closely related to the *Amphipoda* rather than to the *Isopoda*, and are not properly intermediate, nor a new type alike distinct from both."—Vol. i. p. 11.

This author, while from anatomical reasoning he removes the *Læmodipoda* from the position in which they have been placed as a separate and intermediate order between the *Amphipoda* and the *Isopoda*, yet sees in another group, which by every previous naturalist has been ranked with *Isopoda*, a "true intermediate species between the *Amphipoda* and *Isopoda*; and if any third or intermediate group be admitted, these should (he thinks) be considered as constituting it. These species belong to the genera *Tanais*, *Arcturus*, *Leachia*, and others allied."—Vol. i. p. 11. These form the tribe or group of *Anisopoda*, the second or intermediate of that author.

By the force of similar arguments as those which are employed for the removal of the *Læmodipoda* from taking a position distinct from the *Amphipoda*, it is difficult to imagine that so acute an observer as the founder of this new group should separate it from the true *Isopoda* upon grounds so feeble as appears to us to be the case.

But on this we shall enter more at large when we report upon the British *Isopoda*, and at present only observe, that the affinity which the *Anisopoda* holds to the true *Isopoda* in all its more important characters is too close to admit of its being recognized as a distinct and separate group of equal importance. The only feature which appears to approximate it to the *Amphipoda*, the forward direction of the fourth pair of feet, can scarcely, we think, be of sufficient importance to narrow the margin between the *Amphipoda* and the *Isopoda*, there being other characters of greater importance that induce a natural separation strongly marked.

But although anatomical science will not admit the elevation of the *Læmodipoda* or that of the *Anisopoda* into distinct orders or groups equal to that of the *Amphipoda* and *Isopoda*, yet the presence of strongly defined characters, both in development of form and suppression of parts, might safely admit, with great convenience to classification, a separation of the *Læmodipoda* from the *Amphipoda* proper, and the *Anisopoda* from the *Isopoda* proper, each forming a group subordinate to their respective types; and in this Report we propose the following arrangement:—

* Classis CRUSTACEA. Subclassis I. MALACOSTRACA.

EDRIOPHTHALMA (Legio II.).

Order.	Division.	Subdivision.	Group.	Tribe.	Family.	Division.	Subfamily.	Genus.
				Saltatoria ..	Orchestidæ			Orchestia.
							1. Stegocephalides	Montagua.
			Vagantia† ..				2. Lysianassides ..	Lysianassa.
				Natatoria ..	Gammaridæ		3. Tetromatides ..	Tetromatus.
							4. Pontoporeides ..	Sulcator.
		Gammarina					5. Gammarides ..	Gammarus.
							6. Leucothoides ..	Leucothoë.
						Nidifica§	Podocerides....	Podocerus.
	Normalia ..				Corophiidæ	Tubifica‖	1. Cerapides......	Siphonocetus.
			Domicola‡				2. Corophiides	Corophium.
					Cheluridæ ..			Chelura.
Amphipoda....					Hyperidæ ..			Hyperia.
		Hyperina ..			Phronomidæ			Phronoma.
					Typhidæ....			Typhis.
	Aberrantia				Caprellidæ..			Caprella.
Isopoda	Normalia.							
	Aberrantia.							

* This Table is the result of the united labour of Mr. Westwood and the author of this Report, and is the classification about to be adopted in their forthcoming work 'On the British Sessile-Eyed Crustacea'.—C. S. B.

† Which do not live in homes.

‡ Which live in homes.

§ Which build nests.

‖ Which construct tubes.

It will here be seen that it is thought preferable to abide by the older classification, which considers the *Amphipoda* and *Isopoda* as distinct orders of the second division, than as separate groups of the same order as classified by Dana; in this, we think, we are justified upon strictly anatomical reasoning, for there appears to be as great, if not a more distinct separation, between the *Amphipoda* and the *Isopoda*, than between the *Amphipoda* and the higher types of Crustacea.

This latter opinion is one on which Dana is again opposed to Edwards and the older naturalists *.

The former considers the *Isopoda* a higher type of Crustacea than the *Amphipoda*, whereas Leach, Latreille, Desmarest, Lamarck, and Edwards have each respectively placed them next, succeeding the *Stomapoda* in the descending scale.

This difference of opinion involves and necessarily opens the question of the homological relation of parts between the different orders or groups of Crustacea, the discussion of which will enable us, we hope, to see how much or little the same organs resemble each other when adapted to forms higher or lower in the scale; and their closeness or dissimilarity will enable us to approximate toward a tolerably correct estimate of the value of the unity of typical development, and thereby judge the relation which one form of Crustacea may hold to another.

The older European naturalists, and Edwards in particular, consider the *Edriophthalma* as formed upon the same general type as the *Podophthalma*; not so the American carcinologist, who affirms that "they have not a macroural characteristic, but have a body divided into as many segments as there are legs (whence our name *Choristopoda*); the antenna, legs and whole internal structure are distinct in type."—Vol. i. p. 1404.

The consideration of the structure of the *Amphipoda* is one that has little attracted the attention of either naturalists or physiologists. This remark is the more correct in relation to our own country, where, we are not aware that there has yet been published a single communication on the internal organization of this order, except a short paper on the *Caprellæ*, by Mr. H. Goodsir, in the Edinburgh Philosophical Journal for July 1842.

The labours of Montagu were mostly directed to the pursuit of objects, and the important addition of figuring and describing the outward appearances of his results. The attention of Leach was confined to describing, generalising and classifying all known species, whether the result of his own discoveries or that of others. The researches of most later writers have been extended to the elucidation of local faunas only. Dr. Thomson of Belfast read at the British Association, and published in the Annals of Natural History for 1847, a series of papers on the Crustacea of Ireland. Dr. Johnston of Berwick has during an industrious career (alas! too early

* Milne-Edwards.	Dana.
Legio (II.) Edriophthalma.	Subclassis II. Edriophthalma.
Ordo I. Amphipoda.	Ordo I. Choristopoda.
„ II. Isopoda.	Tribus 1. Isopoda.
„ III. Læmodipoda.	„ 2. Anisopoda.
Order I. Amphipoda.	„ 3. Amphipoda.
Family. Gammaridæ. Tribus. Sauteurs. Marcheurs.	Tribus 3. Amphipoda.
Family. Hyperidæ. Tribus. Gammaroides. Anormales. Ordinaires.	Families. Caprellidea. Gammaridea. Hyperidea.

closed) described several Scottish species. Prof. Allman, in the 'Annals of Natural History' for 1847, published a memoir on the *Chelura terebrans*.

But even on the continent the study of these animals has not been a favourite pursuit, and few naturalists have examined for themselves beyond the external form and general arrangement of structure. Hence we find that each of the few actual observers is inclined to adopt some new scheme of generalization for himself, founded on some peculiar fact more or less common to the tribe. This will continue to be the case until the anatomy and development be properly displayed, and their structure demonstrated in comparison with other known types.

The labours of the great French carcinologist are among the best known, and certainly the most recognized and appreciated of any of the systematic works on Crustacea. But the investigations of Kölliker, Müller, and the labours of Von Siebold are valuable both in interest and importance. But these have, probably from their inland position, confined their researches chiefly to the internal structure of the *Isopoda*.

Rathke's contributions to the fauna of the Crimea are not only valuable for the addition of animals from a region that has been little examined, but are noticeable for great accuracy of delineation in minute detail, which make them second to none, if not before all others, in value, for truthfulness and the close observation of the author. But Prof. Kroyer appears to have been the one of all the naturalists who has entered upon the investigation of this order in a manner which induces us to believe that he felt the importance of its close and extended observation, and his great work, entitled 'Voyages en Scandinavie, en Japonie, Spitzberg, et en Feroe,' is a labour, of which it is to be regretted Europe has so few examples.

Recently, Mr. Dana has given to the world a great work on the Crustacea as the result of his researches in the southern seas, where he was sent by the United States Government. This work, of which the plates have only been published since this paper has been in the press, will rank its author as second to no European carcinologist, and during the course of this Report, the work, though but recently obtained, will be found frequently alluded to and quoted.

In furnishing to the best of our opportunities this Report to the British Association for the Advancement of Science, we are aware of shortcomings. These chiefly arise from inability of obtaining foreign works published many years since, and others difficult to be procured. But these faults (not many or important, we hope) might have been more considerable but for the kindness of friends, who willingly supplied us with those in their possession. In this way we are indebted mostly to John Lubbock, Esq., Col. C. Hamilton Smith, C. Darwin, Esq., and J. O. Westwood, Esq.

To study the results of other observers in connexion with a British fauna, it became desirable that specimens should be obtained from as many and distant localities as possible. In pursuance of this plan, we have many valued friends to thank, and if gratitude is to be measured in proportion to liberal communications and generous supplies, then we are most indebted to our highly esteemed correspondent the Rev. George Gordon, Bernie Manse, near Elgin, for many most interesting species, among which are some that are additions to the British fauna, as well as others that are new to science.

Our kind friend, George Barlee, Esq., so well known to naturalists by his dredging results, has sent us many valuable collections from Penzance, St. Ives, and the Arran Isles. So also from the first of these localities we have been supplied by our friend C. S. Harris, Esq., of Budley Salterton, and from Falmouth we have recently been indebted to our excellent friend J. Webster, Esq., for the results of extensive dredgings.

From the coasts of Northumberland and Durham we have received many species through the kindness of Joshua Alder, Esq. From Weymouth we have been assisted by Prof. Williamson of Manchester, and P. H. Gosse, Esq.

To our excellent friend P. T. Smyth, Esq., who not only supplied us with the result of his own industry, but frequently placed his yacht at our disposal for dredging purposes, we cannot be too thankful, since it is greatly through his means that we have been successful in obtaining a very large collection of South British species.

Mr. Boswarva, so well known in the neighbourhood of Plymouth for his knowledge and skill in preserving the marine Algæ, has frequently sent us specimens. So also has our valued friend and companion Howard Stewart, Esq., Student of Anatomy at the Royal College of Surgeons; also his brother, Mr. Charles Stewart.

George Parker, Esq., of Jersey, and recently Mr. Edwards, an industrious naturalist at Banff, and Mr. John Loughor of Polperro, and other kind friends have furnished us with what specimens accident or good fortune may have brought within their reach *.

For the purpose of identifying species with Leach's and Montagu's types we visited the British Museum, where we received every assistance and kindness from Dr. Gray and Mr. White, whose 'Catalogue of British Crustacea' has been a valuable handbook of species, and much used by us in our progress with the subject. Nor can we forget Mr. Kippist, the Librarian of the Linnean Society, who most obligingly procured for us many books of the Society which it was necessary should be consulted.

The Homologies.—In comparing the external organization of the *Amphipoda* with that of the *Macroura*, the observer is attracted by the absence in the former of the great cephalo-thoracic buckler or carapace. This in the higher tribes is the result of the exaggerated development of some of the anterior segments of the head. This loss of the carapace is also accompanied with a separation into distinct annules of the whole of the remaining portion of the animal, whilst the cephalic region, including the seven anterior segments, assumes no greater space or higher importance than any of the other individual segments.

If a careful examination of the cephalic ring be made, it will be found that there evidently are the same relative parts, without that monstrous development which in the higher types produce the carapace.

It has elsewhere been shown †, upon evidence which appears to us impossible to be misunderstood, that the anterior segments exhibited in the carapace, viz. the antennal rings, gradually diminish in importance inversely with the development of the mandibular; that whereas the former build up the larger portion of the carapace in the *Brachyura*, the mandibular segment in the lowest of the Macroura type (*Diastylis*, *Cuma*, *&c.*‡) completes, to the almost total exclusion of the anterior segments, the entire carapace. This increasing development of the anterior or cephalic segments is in accordance with the consolidation of the nervous system, and *vice versâ*, the separation of the nervous cord into distinct ganglia is coincident with a corresponding decrease in the importance of the carapace.

* In the forthcoming work on the British Edriophthalma, we shall identify the species with their habitats upon the authority of our kind friends.

† Annals of Natural History for July 1855.

‡ *Vide* paper on the British *Diastylidæ*, Ann. Nat. Hist. for June 1856.

This law, which regulates the character of the cephalic segments in the higher types, is still persistent in the *Edriophthalma*.

The nervous system below the *Stomapoda* is entirely free from thoracic consolidation, except in the abnormal class of *Cirripedia*. The cephalic region or segments belonging to the organs of consciousness is reduced to a minimum, or represented only by corresponding appendages.

In all the higher types, the antennal segments as well as the mandibular, excepting only the anomalous genus of *Squilla* and its near allies, unite to build up the carapace, the respective relation of each segment to the others differing in importance in distinct orders. This appears to be the same with respect to the cephalic ring of the *Amphipoda*, which homologizes with the entire carapace of the *Brachyura* and *Macroura*, differing from them only in degree.

In the *Macroura* the development of the mandibular segment extends back and covers the whole of the thoracic region, forming so efficient a protection as to render the completion of the dorsal portion of the thoracic segments a work of supererogation. These latter rings in the higher types become so closely compacted together, that, by diminishing their extent, they concentrate their force; whereas in *Amphipoda* the thorax is developed into seven distinct and perfect rings, while the homologue of the carapace reaches not beyond the segment which bears the first maxilliped, and this not by any extraordinary development of the posterior cephalic rings, but by the consolidation of the three segments next succeeding the mandibular into one, which supports the three posterior appendages of the mouth.

Prof. Milne-Edwards * contends that the whole of the seven anterior segments of the animal are fused together and form the first or cephalic ring.

"The exact normal relation of the shell of the head," says Mr. Dana (part i. p. 35 of his great work), "is with difficulty determined; yet the argument that this segment extends across below just anterior to the mandibles, and only here, probably holds in this group, as in the *Decapoda*, so as to show that the shell pertains either to the mandibles or second antennæ: further investigation may possibly bring out a more definite decision."

The effort in this Report will be directed, if possible, to demonstrate that the "shell of the head" is homologically the same as the carapace in the higher types, restricted according to a law of development to be a less important feature of the animal. Gradually it descends from the most perfect forms.

In *Macroura*, a distinct suture, the cervical or epimeral of M. Milne-Edwards, is visible, distinguishing the mandibular from the antennal segments. In *Brachyura* the large development of the antennal segments completes most of the carapace; in *Macroura* the mandibular ring equals, if not exceeds, the half of this structure. This change is produced in the relation of the two parts by a corresponding decrease of importance in the antennal or cephalic portion, rather than by an extraordinary enlargement of the mandibular. As we descend in the scale of Crustacea, we find that the antennal, or that portion supplied with nerves from the cephalic ganglion, diminishes in size in relation to the rest of the carapace, and that the carapace likewise itself loses its importance in relation to the entire animal.

This, which we see being carried out in the *Macroura*, *Stomapoda*, and *Diastylidæ*, where the thorax of the animal is seen gradually in each succeeding form to become less protected by the carapace, appears to reach a limit approaching the extreme in the *Amphipoda*, when the entire thorax is

* Histoire des Crustacés, vol. i. p. 20.

free; not being protected by the carapace, it ceases to possess that resemblance to an internal skeleton, which it receives in the higher types from its peculiar relation to the monstrously developed cephalic rings.

In the *Amphipoda* the upper portion or shell of the cephalic ring is constructed as in the higher types, that is, it is formed of the antennal and mandibular segments, each reduced to almost its minimum of importance.

In *Talitrus* and *Gammarus*, but most distinct in consequence of the larger size in the former, a suture, which most certainly homologizes with the so-called cervical or epimeral suture of *Macroura*, is visible, and shows that the mandibular ring perfects its inferior arch: this forms the epistome of the frontal aspect of the head.

The line of demarcation or suture which separates this segment from the anterior, traverses the lateral walls of the head, parallel with, and but a short distance above, the mandibles, after passing which it rises toward the upper surface, but loses itself in the posterior margin about half-way from the top*. In this respect it bears some analogy to the manner in which it is lost in *Brachyura*, but only in appearance, for there it was the result of a large development of the anterior segments; here both are equally unimportant. In point of fact, the connexion of the *Amphipoda* is much nearer to the *Macroura*; and if a perpendicular line of incision were made to cut away the carapace of *Astacus* just in front of the cervical suture where it exists on the top of the carapace, that is to remove the whole of the carapace posterior to that line, and perfect each ring of the thorax, but for the pedunculated eyes, the *Astacus* would be pronounced among the *Amphipoda*.

The epistome (Plate XII. fig. 1 C) appears with little doubt to be the inferior aspect of the mandibular ring (B), which is seen on the external lateral surface of the head, and which can be identified from the fact of its carrying the mandibles. This relation of the epistome to the mandibular segment is not admitted by Mr. Dana, who rather, from analogy with the higher types, than by direct evidence of the subject before him, identifies the epistome as belonging to the inferior (or external) antennal segments.

We do not think that the evidence in the higher forms bears out this assumed relation; for whilst in the *Brachyura* the two antennal segments and the mandibular, each through the arrangement of their sternal portions, unite to form the antero-oral plate, we find that in the *Macroura* their relative importance is not of equal extent. We think, that as the ophthalmic segment is itself not developed to much importance in the *Brachyura*, and is altogether lost in the *Macroura*, so we believe that the same process of annihilation of parts continues, and that in the *Amphipoda* the only segment in which the sternal portion is persistent is the mandibular. A thin partition of osseous tissue, passing perpendicular in the median line between the antennæ, less important between the superior than the inferior, may possibly represent the sternal part of each of the antennal segments respectively.

The next three pairs of appendages succeeding the mandibles are borne upon a piece which forms the infra-posterior portion of the head (Plate XII. fig. 2 K), and is probably the sternal piece of the segments belonging to the two maxillæ and the maxilliped; the dorsal portion of these segments appears to form an arch within the cavity of the head, as given in Plate XII. fig. 3, and offers a support to the stomach as well as points of attachment for muscles.

In attributing to this internal structure the high relative importance as the

* This suture, though recognized, was scarcely appreciated by us until we had read Dana's work.

homologue of the dorsal portion of the segments, of which it is a part, we think we are justified from a careful observation of its relation to surrounding parts; and it should always be borne in mind, that the relation which the internal organization bears to the external structure is the only sound way of understanding the true relation of individual parts to the whole.

In the genus *Talitrus* the appendages posterior to the powerful mandibles appear to be strengthened by an internal process on either side, which is produced until the two meet and form a ring. It is this ring that we contend to be the homologue of the three posterior segments of the cephalic division: that it is dorsal and not sternal, is demonstrated, we think, from the fact that the nervous cord passes through the hollow, though to accomplish this a considerable depression from its normal direction is produced.

Thoracic segments (*Pereion**). The seven annules which posteriorly follow the cephalic portion are in the higher order protected by the carapace. These become less so in the descending order; and in the *Amphipoda* each segment is formed into a perfect ring, analogous in appearance to the abdominal segments in *Macroura*.

The anterior of these thoracic segments differs in its position from those which are posterior, by the circumstance, that the anterior margin overrides the posterior edge of the cephalic, whereas in all the subsequent ones the anterior dips beneath the posterior edge of the annule immediately preceding, the two margins being united by a thin membrane sufficiently elastic to admit of one plate passing to a small extent beneath the next.

The several appendages supported by these segments are locomotive in their character, sometimes more perfectly perambulatory, at others adapted for climbing and grasping, under which character the two anterior are most constant in their adaptation; and the probability is that they are never used except as supplying organs to the mouth, unless to assist in climbing occasionally.

On each side of the several annules of the thorax, the *Amphipoda* are remarkable for the development of a large scaliform appendage, which Prof. Milne-Edwards, and hitherto every author after him, consider to be epimeral or side-pieces of the dorsal arch, of each respective segment, remaining unfused. These so-called epimerals we exclude from being a portion of the true segment, believing them, as we think we shall be able clearly to demonstrate in the proper place, to be the first joints or coxæ of the legs.

Abdominal segments (*or pleon*†).—The next succeeding seven rings form the so-called abdomen of all later carcinologists, but they support three very distinct kinds of appendages.

In the *Brachyura* the appendages are all of one sort, and these all present only in the female, and are adapted to a special function connected with the process of reproduction. In the male they are absent, except the two anterior pairs, which are modified so as to adapt them to fulfil the office of intromittent organs. As we descend in the scale from perfect development, we perceive that the posterior annules are constructed and arranged so as to become a tail piece, and a powerful and efficient organ it is in the *Macroura* and *Anomoura*, which enables the animal to dart or swim through the water with considerable force and velocity.

The number of segments which are arranged to complete the caudal appendage differs in separate orders. In the *Brachyura* there is but one; among the *Macroura* the two last segments are so arranged; but among

* From περαιόω, *to walk about*: pereion, part which supports the walking legs. This and the following are suggested instead of the old and incorrect synonyms of thorax, abdomen, &c.

† From πλέω, *navigo*: pleon, part which supports the swimming legs.

the *Amphipoda*, there are four so constructed as to form a tail. Of these four, three pairs are arranged upon the same type; the other, which is the extremity, or twenty-first ring, can only be contemplated in the character of an obsolete segment with its rudimentary appendages.

Thus the segments which form the abdomen support three distinct forms of appendages. Three anterior are constructed upon one type, three succeeding upon a second, and the last, which for convenience we shall designate by the name of Telson (from τέλσον, *extremity*), upon a third; or, perhaps to speak more correctly, it is a rudimentary appendage, modified upon the type of the preceding three.

Thus we perceive a singular coincidence, that the most anterior as well as the most posterior segments of the animal are annihilated and represented by their respective appendages only, a circumstance which appears to reverse the law in embryological development in this class of animals, where we find that the earliest developed parts are the anterior and posterior extremities of the animal, the intermediate segments being the result of subsequent growth.

Having compared the twenty-one segments of the crustacean type with those of the *Amphipoda*, it will next be desirable that we should see to what extent the separate parts or appendages may or may not differ from those in the other forms.

Organs of vision.—The first normal segment of the typically perfect Crustacea is represented in the *Amphipoda* by its appendages only; the eyes, which appear to be lodged between the two pairs of antennæ, are homologically anterior to the antennæ, and are supplied with nerves which are the most anterior pair given off by the cephalic ganglia.

In the higher orders the eyes are projected upon footstalks. In the *Amphipoda* they are sessile. This distinction between the two has been thought by naturalists generally to be an important signification in relation of one tribe to that of the other; hence the feature has been made available as a demarcation of distinct orders, it being taken for granted that so visible an alteration in these organs must be accompanied by considerable and important changes in other parts of the structure.

The eye in relation to the typical animal must be viewed as an appendage of the first normal segment peculiarly developed to perfect its adaptation for the fulfilment of certain requisite conditions; after the same manner, the mandibles, chelæ and feet are necessary forms for other uses.

In the *Brachyura* an ocular appendage consists of two articulations, at the extremity of which the eye is lodged, in the same manner as we might presume the hand would hold a ball, or, to give a more correct idea, be developed into a ball having power of vision.

It appears to be a law in the decreasing structural importance of Crustacea, that the segment supporting the appendages shall disappear before the appendages that it supports; thus in *Macroura* the segment has disappeared, but the eye is still borne on footstalks. In the *Amphipoda* it appears that the eye alone remains; the segment and the articulating portion of the appendage not being developed, the eye is presented so deeply within the segment succeeding, that it appears to be behind the antennæ. But its position, wherever situated, can only be to meet peculiar advantages under certain conditions. Thus in the genus *Talitrus* the eye appears to be nearly at the top of the head, while in *Erichthoneus* and some of the *Podocerides* it is carried upon a projecting inferior angle, which in some genera of this subfamily is considerably developed in advance of the head; in which position, in consequence of the insufficient depth of structure, the eye projects upon the internal surface, where it is lodged in the form of a protuberance.

In the genus *Tetromatus*, which, we believe, is now for the first time added to our knowledge, there are four simple eyes, two upon each side of the head, instead of one made up of many facets, as is usually the form of the organ in this class of animals. But this seeming anomaly appears not to be without explanation.

In the young of the *Amphipoda* the number of facets is fewer in the eye than in the adult; the number of the lenses therefore increases with growth. In the genus *Gammarus* the early numbers are eight or ten, whilst those of the adult are from forty to fifty. If we suppose that in *Tetromatus* there were but two crystalline lenses developed in the larva, a consequent arrest of development at this particular stage would limit the number in the adult to those already present in the larva, and which therefore, we think, must be looked upon rather as two distant lenses of the same eye, than as distinct organs of vision, although to external observation they assume the appearance of two separate eyes (Plate XIII. fig. 8). The coloured cornea is very distant from the lenses.

In this genus the crystalline lens is developed in the integumentary structure of which it forms a part; in this arrangement the condition of the eye differs from that of any other among the *Amphipoda*. Close observation may detect a lessened approximation of like condition in *Anonyx Holbolli*, but there only a semi-transparency, like a single small lens, exists.

The sessile character of the eyes in this order appears chiefly to rest on the pedunculated feature being absent rather than in any definite alteration of the eye itself, and by no means is it to be considered as evidence of organs of vision indicative of a lower class of animal. This we think is easily demonstrated by the fact, that in all the *Diastylidæ* the eyes are sessile and converge into a single organ; this is the case also with some of the *Entomostraca*, whilst, on the other hand, the genus *Tanais* among the *Edriophthalma*, and *Artemia* among the *Entomostraca*, have the eyes supported on footstalks in a manner corresponding with the higher types.

The internal or first antennæ.—These organs are invariably constant in the order *Amphipoda*, although in the genera of *Orchestia*, *Talorchestia* and *Talitrus*, they are so unimportant as to be little more than rudimentary appendages. They belong to the second normal segment, which in the *Amphipoda* we believe not to be developed, or, if present, fused so completely with the next succeeding, as not to be distinguished from it.

The anterior antennæ typically consist in all Crustacea of a peduncle formed of three articulations, all of which are present in the *Amphipoda*; and a filamentary appendage more or less extensively developed, and one or two secondary filaments of greater or less importance, of which latter in the *Amphipoda* there is never more than one, and that is generally rudimentary, often obsolete, and perhaps more frequently absent than present. But this secondary appendage appears to fulfil but an unimportant office even in the higher orders, whilst in the *Amphipoda* it consists of but a few short articulated joints furnished at the extremity of each with a few hairs of a form similar to others peculiar to the species.

It therefore differs from the principal filament or *tige*, as it is named by M.-Edwards, which, except in the subfamily of *Pontoporeides*, is developed to a much greater extent, and in addition to the simple hairs, is furnished with a considerable number of membranaceous cilia, which appear to be peculiar to this organ in Crustacea. The forms of these cilia vary in certain species, and will be more particularly described when it becomes necessary to consider the especial senses of the *Amphipoda*. We shall only here remark, that they appear to us to be active agents in communicating a consciousness analogous to sound to the auditory nerve, and on this account we shall allude to them under the name of *Auditory Cilia.*

Professor Milne-Edwards considers the presence or absence of the secondary filament or palp as a circumstance of little importance, and affirms that naturally the genus *Amphitoë*, without this appendage, is extremely near to *Gammarus*, in which it exists, if they be not in the same genus*; the separation being admitted for the convenience of classification only.

But from this our experience compels us to differ. The two filaments, however unequal, homologize with those in the higher order, where sometimes a third is added, two of which are, to the extent of our present knowledge, always constant. We therefore can but view the presence or absence of this palp, however rudimentary the form in which it may exist, as demonstrative of some change in the habits or condition of the animal, which must be accompanied by structural alteration of a more or less important character. It must therefore show a separation between animals that vary in some essential conditions, even though not very visible features.

Thus it will be found upon a close examination that *Amphitoë* is separated from *Gammarus* by important essential qualities (which will be described with the animals in our forthcoming work on this subject in conjunction with Mr. Westwood). Here it is sufficient to observe, that the habits of *Amphitoë*, as well as its structure, are closely allied to those of the genus *Podocerus*, and that they both exist in a division (*Nidifica*) of the family *Corophiidæ*, which division we have thought desirable to construct, that those *Amphipoda* which live in nests of their own construction may be separated from those which live in tubes, or burrow, such as *Cerapus* and *Corophium*.

The second or external pair of antennæ.—These organs appear to us to be the most anterior appendages, which are supported in the *Amphipoda* upon a segment that is present, and which forms almost the entire cephalic region.

One of these antennæ consists typically in the order of a peduncle and a solitary filament. The peduncle consists of five articulations. In some, as the *Macroura*, there is attached a moveable scale; and in others, as the *Anomoura*, a spine exists on the basal portion of the antenna: these appear both to be represented in the larva of the *Brachyura*, and at an early period of this stage are more important than the principal appendage of the antenna itself. These secondary parts are absent in the *Amphipoda*.

The first or basal joints of this organ in the *Brachyura* are very generally fused together, and with the nearest approximating part of the calcareous skeleton of the animal; this fusion is sometimes so perfect, that no mark of distinction is apparent to distinguish the antenna from the body of the animal: this is particularly correct of the *Leptopodiadæ*. But this close union between the parts of the antenna and the body of the animal lessens with the degradation of the creature, until we find the five articulations separate from each other and distinct from the animal. This is the case in the *Macroura* as well as *Amphipoda*.

But even in this order, *Amphipoda*, in many species it is with difficulty the demarcation between the two first or basal articulations can be made out, so intimately do they appear to be connected together. From the first of these a strong tooth or spine is commonly developed, in some more importantly than in others; this denticle is the external portion of the olfactory organ, and homologizes with the olfactory tubercle (auditory of M. Milne-Edwards, Von Siebold, &c.), which is situated on the basal portion of the antenna in the *Podophthalma*.

* Histoire des Crustacés, vol. iii. p. 28.

The two first articulations, without being actually fused with the anterior integumentary tissues, are sometimes so closely incorporated with them, as to be lost, except to close analytical observation. This is the case in the family of *Orchestidæ*, which has long been described by authors as having but three articulations to the peduncle of this antenna; but the other two may be seen to exist in the upright anterior walls of the head, of which they form the largest portion (vide Plate XII. fig. 1 = H first articulation = P second = G third and fourth). A similar conclusion is *almost* arrived at by Mr. Dana (Part II. p. 848). He says, "C [answering to P in our figure], an area adjoining the antennæ, having a membranous covering and properly a part of the base of the outer antennæ; *d* [answering to H in our figure], a shelly area either side of *e* [C], or epistome*." This shelly area he has failed to perceive, equally with P, is part of the base of the outer or second pair of antennæ. These articulations are so closely impacted with the head as not to be observable to a lateral examination of the animal, being as they are absorbed into the cephalic region. It is this peculiar arrangement of organs in this family that pushes, as it were, the whole of the anterior organs to the top of the head, placing as it does a more than usual distance between them and the oral appendages.

The filamentary termination of this antenna in the *Amphiphoda* is invariably solitary and generally multi-articulate. It obtains its most filamentary character in the true *Gammari*, but in some genera the whole of the numerous articulations of which it is constructed become consolidated.

The first approximation toward the strengthening character of this organ, exists in the true *Amphitoë*, whence, by its near allies through *Podocerus*, it arrives at its fulminating point in *Corophium* and *Chelura*, where they are completely fused into a single articulation (vide Plate XIII.). In such cases they are powerful assistants in enabling the animal to climb over uneven surfaces, and probably assist in the construction of their abodes, whether burrowing, as *Chelura* and *Corophium*, or forming tubes, as *Siphonocetus* and *Cerapus*, and probably also *Erichthoneus*, or in building nests, as *Amphitoë* and *Podocerus*; and to adapt them more completely to their work, they are often supplied with hooks towards the extremity (Plate XIII. fig. 6 *a*). These are formed by the consolidation of some of the capillary armature into strong curved spines; the best examples that we have observed are in *Podocerus*, where they must become an additional means to the power of the antenna.

In all Crustacea this pair of antennæ appears persistent and generally well developed; we are not aware that there exists in any of the *Gammarina* of this order, or among the aberrant family of the *Caprellidæ*, a solitary instance of its being reduced to a rudimentary or obsolete form.

This remark appears to be true of *Isopoda* as well as *Amphipoda*, if we remove from each the parasitic forms, such as the *Hyperia* among the latter, and *Bopyrus* and its allies among the *Isopoda*; a circumstance, which induces us to believe that the second antenna is the seat of a sense which undergoes but slight modifications to enable it to be equally efficient whether in air or water, since the *Orchestidæ* live entirely out of the water, as likewise several species of *Isopoda*.

The mandibles.—These are the next succeeding appendages, but are separated from the last by the epistome and labium.

The former (epistome) is generally placed in the *Amphipoda*, vertically in the anterior wall of the head; occasionally it is produced into a spear-like

* The Plates to Mr. Dana's work having been published since this has been in the press, we have only known the references to them by the text of his work.

process, as in *Anonyx ampulla* (Kroy.); but in the more common forms it appears as a plate across the anterior portion, as if it gave strength and solidity to the structure. As before observed, this is the sternal aspect of the mandibular segment, and acts as a fulcrum to the labium and anterior portion of the mandible.

The labium is divided into two parts, the upper and the lower. The line of separation appears to be an imperfect hinge enabling the lower portion (E, fig. 2, Pl. XII.) to possess a slight opening and closing power, which co-operates with the mandibles in collecting materials into the mouth.

The margin of the labium is generally fringed with hairs. In *Gammarus gracilis* many of these are club-shaped and cumbersome in their appearance.

The mandibles are powerful organs which impinge at their extremities one against the other, the biting edge being in the median line, and developed into a series of denticles or teeth-like processes (Pl. XIV. fig. 6 *b*); these vary in form, in some considerably, and perhaps less remarkably in all genera. Within the denticulated extremity a second process commonly exists (Pl. XIV. fig. 6 *c*), like a repetition of the first. It appears not to be always present; but when it is, the plate is articulated by a free joint with the mandible, and is capable of a certain amount of movement. Situated about the centre of the posterior margin stands a large projection, which meets a fellow in the opposite mandible, and is evidently adapted for mastication; it may with propriety be called the molar tubercle (Pl. XIV. fig. 6 *a*). It forms with the anterior denticulated edge the two extremities or horns of a crescent. The second or articulated process is placed between the two, but nearer to the anterior teeth. This intermediate plate appears to be constructed so as to pass the food from one to the other, from the biting to the grinding surfaces, between which there are curved spines (*d*) to facilitate the movement.

The two mandibles are brought into contact by powerful muscles, which are attached to the inner surface of the dorsal portion of the cephalic ring, and homologize with those attached to the long calcareous tendons in *Macroura*, which have their muscles secured to the inside of the carapace.

The surface of the molar tubercle is covered over with rows of teeth-like processes, so minute that they can only be defined by a quarter-inch power object-glass. The arrangement of these teeth is tolerably constant, being in rows more or less even. At the lower portion the teeth are larger, the outer row being most conspicuous; the size diminishing, row after row, until towards the higher limits, their importance has so fallen away, that they can with great difficulty be distinguished at all. In some species there is added a filamentary appendage to this tubercle, the margin of which is ciliated with minute hairs. Perhaps this may be in some way connected with taste.

The mandibles are no exception to the general law among the Articulata, that all the appendages are modified legs; the mandible itself homologizing with the ischium or third joint of the perambulating leg, and the same in the gnathopodite of the recent acute but cumbersome homological nomenclature of Prof. Milne-Edwards, the maxilliped of authors generally.

That the third joint is the correct homologue, unless the second be fused in common with it, we think can be demonstrated by the fact, that in the *Macroura* the ischium of the third gnathopod (maxilliped) has the inner margin furnished with teeth which impinge against the similarly denticulated edge of the corresponding member, and assumes the character of a not very imperfect biting apparatus.

In the mandible of the *Amphipoda* the parts are developed into an efficient and powerful organ; the denticulated margin has the teeth more strongly defined where their office is most required, but absent where not wanted.

In some, as *Anonyx denticulatus*, the anterior teeth are reduced to a smooth cutting edge; but we have failed to detect that any relative form is dependent upon the character or kind of food which it may be the habit of the animal to prey upon. The *Talitri*, which are known to be carnivorous, appear to differ in no important feature from those which are believed to live on marine vegetables, as is the case with the *Gammari*.

The ischium being developed into the necessary or important part of the mandibles, the remaining articulations of the typical appendage are reduced to an obsolete form, and in some of the *Amphipoda* are entirely wanting. This is the case in the family of *Orchestidæ*, a circumstance from the, at most, amphibious character of the group, which suggests the idea, that it is efficient only to those which inhabit the water, from scarcely any of which among the *Amphipoda* is it wanting, as far as our experience goes. The use of this appendage is, perhaps, to direct floating material more readily towards the mouth. The organ generally is raised and lies between the lower pair of antennæ.

The Maxillæ.—These are separated from the mandibles by a posterior labium (Pl. XV. fig. 2), which differs from the anterior in being cleft in the centre, but probably cooperates with the mandibles in the process of manducation.

The maxillæ are two pairs, the first or anterior, and second or posterior. They are extremely delicate leaf-like organs, and by no means fulfil the idea suggested by their name.

The segments of which they are appendages, together with the next succeeding, the first maxilliped, are fused together and concentrated around the mouth.

The *first maxilla* consists of three foliaceous plates (Edwards has figured a fourth in this same species, *Gam. locusta*); the basal is developed upon the second articulation or basis joint of its homological position of the leg; the coxa being, we presume, suppressed from a tendency we observe in Crustacea generally to a fusion of this articulation with the main trunk of the animal, rather than with the appendage of which it forms a part. The second foliaceous plate is developed upon the third joint or ischium in the homological character of the leg, and therefore represents the veritable portion of the mandible (Pl. XV. figs. 3, 4, No. 5). The third leaf-like plate consists of two joints, the fourth and the fifth, the meros and the carpus. This last represents the appendage to the mandibles with the anterior joint or propodos suppressed. The extremity of each plate is fringed; in the anterior or third it exists in the form of five or six short stout teeth. The middle have likewise teeth, but these are more numerous, and exist in two rows; the teeth are long, and each has the point slightly curved, having the anterior edge itself furnished with three or four smaller teeth. The first or posterior plate is furnished with a thick row of hairs, the anterior portion of which is extremely plumose and bushy.

The *second maxilla* consists of two foliaceous plates only, which latter homologize with the first and second of the anterior maxilla; they are extremely delicate and furnished on their anterior margin with stout hairs, which generally are slightly ciliated.

In the genus *Sulcator* (but whether it holds through the whole of the subfamily of the *Pontoporeides*, we have not experience to guide us) the posterior plates of both pairs of maxillæ are folded so as to become two or three parallel leaves, one of which, in the first maxilla, is developed into a prominent lobe, the contents of which are large cells apparently of a secreting kind; but of the office or use of the organ we have met with no analogy among Crustacea to guide us.

The Maxilliped.—We here retain the older name in order to distinguish between the two next succeeding members. This is the last of the three appendages which are supported by the same ring. It homologizes with the first or anterior maxilliped in the *Macroura*, but as an operculum fulfils the duty of the third or posterior, and properly belongs to the cephalic division.

The basal joint and the next succeeding are foliaceous in their development and furnished with hairs; that of the third joint or ischium is also supplied with small denticles or teeth; these vary considerably in form, and we think may be used as a valuable adjunct to other circumstances as a test for species (vide Pl. XVI. fig. 6, No. 3, and Pl. XVII. D, fig. 1 to 5), of which advantage will be taken in the forthcoming history of Sessile-eyed Crustacea.

*The Gnathopoda**.—The (so-called) thoracic members consist of seven successive pairs, which generally throughout the *Amphipoda* are developed upon analogous types, and assume to appearance the character of organs more or less perfectly adapted for perambulation. These seven pairs represent three separate forms; the two anterior, with a few exceptions, are developed into more or less perfect prehensile organs, and homologize with the two posterior pairs of maxillipeds of the higher types of Crustacea, and like them their chief use appears to be as organs attendant upon the mouth. For the sake of distinction from the posterior pairs, we shall adopt the name given to them by M. Milne-Edwards, of gnathopoda, as being singularly appropriate for these subcheliformed organs.

In swimming, walking or climbing, unless perhaps to overcome any extraordinary difficulty, the two gnathopoda are always at rest, being folded up and overlying the external oral appendages.

Perhaps no member in the whole range of Crustacea in one order undergoes such a variety of modifications adapted to one end, more or less complete, as is to be found in the gnathopoda of the *Amphipoda*. They vary from the simple finger and thumb of the perfect chela to the rudimentary or obsolete form, in which the hairs that ornament it are more important than the impinging process itself. Sometimes the prehensile character depends upon the dactylos or finger being reflected back and impinging against the propodos, either of which may have its edge of contact simple or serrated; sometimes antagonistic to the point there is a minute denticle, a rudiment of the thumb-like process, which upon full development completes the normal chela of the higher types. The most constant position for this tooth is at the extremity of the anterior inferior angle of the propodos, to the portion between which and the articulation of the dactylos, we shall limit the signification of the palm. Occasionally the thumb is the result of an analogous development of the next succeeding joint, the carpus, as we find to be the case with *Cerapus* and *Erichthoneus*, or of the still anterior articulation, the meros, as is the case with *Lonchomeros*; in which examples the prehensile claw is formed with one and two intermediate articulations existing between the two impinging extremities.

The first of the gnathopoda is generally the less important of the two, though not invariably, as in the genus *Lembos*. It is moreover occasionally developed, as in *Talitrus* and *Lysianassa*, into a simple foot; a feature that we are not aware is ever the case with the second, which generally is the more important organ of the two. Occasionally, as in *Talitrus*, *Anonyx*, *Lysianassa*, &c., the cheliform character of the second foot is very rudi-

* This includes the two first thoracic feet of authors.

mentary; but as far as our experience goes, it is never developed into a perfectly simple foot. The nearest approach may be in *Tetromatus*.

These two pairs of members are formed most commonly upon the same type, those of the same pair are invariably alike. Once or twice we observed indications of a variety of form between those of the same pair, but these we were induced to consider as the result of an abnormal condition of the part rather than a constant feature in the species.

Even between the sexes the form of these members exhibits a very marked similarity, though the rule is not constant. We see in *Orchestia littorea* that the second pair of gnathopoda in the male are furnished with large powerful claws; whereas in the female they are scarcely more than rudimentary, and assimilate in form to those found in the larva of this species. The realization of the same may be found in a few other species, but still the prevailing rule admits of little variation even where any exists.

*The Pereipoda**, or walking feet.—The two next succeeding pairs are the first true perambulating feet, and are always developed simple in the *Amphipoda*, unless there may be an exception in the genus *Phrosina*. The first homologizes with the great claw in the *Macroura* and *Brachyura*; and both are in all the swimming *Amphipoda* less important in their peculiar character than either those which are anterior or posterior to them; but in those which use them more in walking, which include many of the *Corophiidæ*, they are larger and stronger. Their action is directed forwards, similarly to the two gnathopoda or anterior pairs of feet.

The three next pairs of legs are the last belonging to this portion of the animal, and are the powerful perambulators in *Amphipoda*; generally the last is the longest, but not invariably so; in *Phoxus* it is almost obsolete. They differ from the anterior in being directed backwards, and having each the thigh or basal joint developed into a scale-like process.

Among the more important features which are peculiar to the legs of the *Amphipoda*, and perhaps to the whole of the legion of *Edriophthalma*, and identify them as distinct from the *Podophthalma*, is, that every joint is so constructed that the whole leg can move only in its own plane. The legs of the *Podophthalma* are arranged to admit of greater freedom in their action; they can bend them in almost any direction. Independently of this peculiarity, there are others equally characteristic of the order.

The separate parts of which the leg is constructed are unequal in their respective lengths as well as different in form in the separate orders. The basal joint in *Podophthalma* is extremely short and unimportant in appearance, whereas among the *Amphipoda* it becomes perhaps the most powerful and conspicuous of any, as may be seen by reference to the table representing the homologies of the leg in Crustacea (Pl. XVI. figs. 2, 3, &c.). Moreover it is often so developed, as, when folded up, to receive the extremity of the same leg within a groove, and sometimes, as in *Acanthonotus*, the propodos is completely buried and protected from accident.

The knee or bending articulation, which admits of one portion of the leg being folded upon the other in the *Brachyura*, takes place between the meros and the carpus: in the *Amphipoda* it takes place between the ischium and meros; but the greatest individuality in the character of the legs of the *Amphipoda* proper, as well as the *Isopoda* proper, and which, we think, has led to error in the appreciation of the true position of these creatures in the class Crustacea, is to be found in the development of the coxa or first joint of the leg; the epimerals of authors generally, and Prof. Milne-Edwards in particular.

* This includes the five posterior thoracic feet of authors.

The coxa in *Brachyura* is universally fused with the segment of the body, so that its normal form cannot be distinguished; in the *Macroura* it is free: it is here we are enabled to make out that the normal number of joints in the legs of Crustacea is seven, which only vary by suppression of the last or fusion of the first with the body of the animal.

In the *Amphipoda*, except the aberrant tribe of *Læmodipoda*, the coxa is always developed into a scale-like process, and has been always considered as side-pieces complementary to the segment of the body to which the legs belonged, and received the name of epimerals or side-pieces by M. Milne-Edwards.

These so-called epimerals, we think, we shall here be able to demonstrate, are homologically the coxæ of the legs, and represent the first joint in the typical condition of Crustacea. But this is so contrary in its description to the opinions of all the highest authorities, that it is necessary we should produce good evidence of the reason why we are induced to affirm that the scale-like form belongs to the first joint of the leg, rather than to the segment, of which the leg is an appendage.

The normal number of joints is most conspicuous in *Nephrops* and *Homarus*, where the coxa is an articulating joint, but appears to have no very great extent of movement. In the *Brachyura* and the *Læmodipoda*, that is the *Aberrantia* of the table accompanying this Report, the coxa is fused with the body; but in the *Amphipoda* it is *fixed to*, but not *fused with*, the segment.

There is a peculiar tendency among the *Amphipoda* to a development of a scale-like form to the joints of the legs in general, a fact which is recognized as a constant feature in the *basis* joint of the three posterior perambulating legs.

This is occasionally the case with the same joint in other legs, as in *Podocerus*, but appears to reach a culminating point in the genus *Sulcator*, where there is a peculiar tendency to this kind of development in almost every part of the visible members.

The object of this peculiar development seems to be for the protection of the branchial organs, which are suspended from the inner surface of the legs, and would otherwise be liable to accidents, particularly to such animals as *Sulcator arenarius*, whose habitat is in the damp sand.

But the chief object which here we have to demonstrate is, that this scale-like development belongs to the leg and homologically is the first joint (or coxa), and that it is not a lateral or separate portion of the annular segments of the body of the animal, and, in fact, that no side-pieces or epimerals exist; to this end we think we are justified by the following arguments, which we shall endeavour to substantiate:—

1st. That seven joints are the normal number in the legs of all the Malacostracous Crustacea.

2nd. That the branchia is normally an appendage of the leg and attached to the coxa.

3rd. That the moveable power of the leg is always between the coxa and the leg, and never between the coxa and the body.

4th. That the coxa (the so-called epimeral) in *Amphipoda* overlaps the segment to which it is attached, and except by a small portion only, is not united by the whole of the margin in juxtaposition with the segment.

5th. That there are no epimerals where there are no legs.

6th. That epimerals are found in no other type, except the *Edriophthalma* among Crustacea.

1st. *That seven is the normal number of joints to a leg*, we think we have already disposed of, in comparing the leg of the *Macroura* type with those of Crustacea generally, and *Amphipoda* in particular, which is better and we think fully explained in the table of the homologies in Plate XVI.

2nd. *That the branchia is normally an appendage of the leg and attached to the coxa.*—This is readily observable in the *Amphipoda*, but not so distinct in the higher types, inasmuch as the organ is developed within the walls of the carapace and possesses an internal character. But this internal character is one of appearance only, dependent upon the monstrous growth of the carapace, which covers the rings and the branchial appendages also. Therefore, whenever the anterior cephalic segments cease to be developed into a carapace or protecting buckler, the branchial organs must be external, which in reality is their homological position even in the highest developed forms.

In the *Brachyura* and *Macroura* the branchial organs are lodged in a cavity formed by the carapace, but they are separated from the great cavity containing the internal viscera by the wall of the segments belonging to the (so-called) thorax. These segments are not complete in their structure, but still they are a portion of the external skeleton, and the branchial organs developed upon their outer surface are homologically the same as the branchial sacs on the inner side of the coxa in the *Amphipoda* ; and the probability is that the disarrangement exists in the higher type, in order to meet certain conditions which enable them to fulfil the more complete function of internal gills. The typical character of the branchial organs in Crustacea is an external apparatus.

The coxa in the *Brachyura* is anchylosed with the segment of the body. In *Macroura* it is free; consequently we can the more readily perceive the attachment between it and the branchia. The flabella in the same orders, which are nothing more than an altered gill, originates from the same joint, and every fact proves to demonstration that the true homological position of the branchia is in connexion with the coxa (Pl. VIII. figs. 2, 3, 10).

Admitting then that the branchial organs are appendages of the legs attached to the coxæ, we perceive at once, since they are attached to the (so-called) epimerals, that these epimerals must homologically be consonant with the coxæ of the *Macroura* type, and therefore the first joint of each leg.

3rd. *The moveable power to the greatest degree is between the coxa and the next succeeding joint, and never between the coxa and the animal.*—This is most apparent in the *Brachyura*, where the coxa is fused with the segments of the body. In the *Amphipoda* it is not fused, but fixed, and the greatest freedom of motion to the legs is where the next joint is articulated with this, which is so frequently close to the base, that it is highly probable that a hasty examination of some of the more common species only, such as *Talitrus* and *Gammarus locusta*, might delay the acceptation of a fact urged by an unknown individual in opposition to the long-received idea propounded by the highest authorities and admitted by all others (vide Pl. XV. fig. 8). But if the very transparent and by no means rare species of *Gammarus grossimanus* be examined, the coxa will be found to have the scale-like form developed to a moderate degree only ; and unlike most of the common species, the basal joint articulates with the coxa almost at the extremity, and gives to the latter so much the character of being a portion of the leg, that if all others of the class had been the same, we doubt if any observer would have thought of describing them as epimerals or side-pieces of the true segments. This remark will also hold in relation to the three posterior legs of *Amphipoda* generally, where the coxæ are developed to a small degree; also in the group *Aberrantia* (*Læmodipoda*), where each is fused with the rest of the animal, as we find it is the case in *Brachyura*, a circumstance which demonstrates that a fusion of the parts of the leg with the body is no evidence of a more or less perfect type of Crustacea.

4th. *That close examination shows that the (so-called) epimerals are not united to the segments in a manner which would be the case if they were merely separated parts of the same segment* (Plate XV. fig. 8).—It is but natural to suppose, whenever, in the structure of a segment, it is necessary that a line of demarcation, from incomplete union by an arrest in the development of the whole, must exist, the two separated portions would continue in the same plane. But these coxæ articulate with their segments by the length of at most one-half of the width of the segment only, and that upon the inner portion. It is this line of demarcation which splits when the animal throws off its exuviæ, and leaves the coxæ attached to the legs, a fact which shows that a closer connexion exists between the leg and the scaliform coxa than between the coxa (epimeral) and the body of the animal.

5th. *There are no epimerals where there are no legs.*

6th. *Epimerals are not observed in any except the* Edriophthalma.

These two last arguments are negative in their character; but it is at least curious, that if the coxæ are side-pieces of each successive segment, a more perfect development of the segments with the side-pieces takes place posteriorly where the perambulating legs cease to exist. Again, their absence in the *Macroura* (for we consider it a thing proved that the so-called epimerals appertaining to the carapace are in fact the mandibular segment*) is at least remarkable both in the anterior and posterior portions of the animal.

Posterior to the perambulating legs, the pleopoda or swimming-feet are attached to the underside of what is commonly called the abdomen, but which we think with more convenience may be called the pleon, being the segments which bear the swimming feet.

The superior arches of the segments overlie the side of the inferior to a considerable extent, but there are no traces of anything like independent side-pieces or epimerals.

Taking these several facts into consideration, we are forced to the conclusion that the epimerals of Milne-Edwards are not lateral pieces of the normal segment, but the first joint of the true legs, and homologize with the coxopodite of the same author in the *Brachyura* and *Macroura*.

In the *Amphipoda* the coxa is developed into a scale-like form common to the whole order, and is produced to a much greater extent in the four anterior than the three posterior legs. The three last have generally the second joint (basis) developed to assume the scaly appearance which belongs to the anterior coxa.

In some species, as in Montagua, one or two of the anterior coxæ are developed so as to hide the whole of the rest of the inferiorly situated parts of the animal.

On the microscopic Structure of the Integumentary Skeleton.

In all Crustacea, from the highest to the lowest, the composition of the tissues is the same.

From its capability of withstanding the disintegrating power of boiling potash as well as that of the mineral acids, the base of the structure is assumed to be chitine, developed in the form of cells, the hollows of which are filled with carbonate of lime.

The process of development appears to be analogous to that of the higher

* Annals of Nat. Hist. July 1855, and in Dana on Crustacea.

forms of Crustacea, but the tissue is never consolidated into so firm a structure. It seldom, except in the larger species, and in certain parts of others where strength is required, as the chelæ, &c., increases to such an extent as to cease to be transparent. This circumstance offers to the observer very valuable advantages. Without necessarily destroying life, one is enabled to perceive the currents of the circulation of the (so-called) blood; also the motion of the cardiac vessels, and the position of many of the internal organs, which otherwise could never be clearly ascertained; since in the dissection of an animal so small, a great disarrangement of the tissues must necessarily take place.

Independent of the advantage of being able to see through the dermal tissue, we are also capable of examining its minute composition, and the manner in which it is built up, without cutting the material into thin sections, and thus precluding the examination of its character as a whole. The examination of this tissue microscopically is one of considerable importance, as we believe it will be found to offer very extensive varieties of structure, the extent of which is limited only perhaps by the number of species in the genera; for as far as our examination has progressed, we have found the law of peculiarity of structure constant to every species, a circumstance in itself of great advantage in the determination of doubtful specimens.

Although a great dissimilarity of the microscopic structure between species belonging to the same genus is persistent to such an extent, as to differ widely even when the general appearances of animals assimilate so that they may be mistaken otherwise for the same species, yet we find that in different genera the character of the structure of the dermal tissue is repeated with but little modification; as compare *Gammarus* (*Othonis*?) with *Chelura* (Plate XVII. figs. 6 & 10), also *Dexamine* with *Calliope Leachii* (figs. 2 & 3) in the same table.

The closely allied species, which by Leach in his typical collection in the British Museum are arranged under the same head as *Gammarus locusta*, will be found, in spite of the very near resemblance in external character, to have a considerable variation in the microscopic appearance of the integumentary tissue, and are in fact two species, *G. locusta* and *G. gracilis*.

In *Gammarus locusta* the dermal skeleton will be found, when examined under one-fifth of an inch power object-glass, to possess a minutely granular appearance in its general aspect, studded here and there with small short arrow-headed spinules or hairs, around each of which is a semitransparent areola, it being free from granular material. In addition to the arrow-headed points, which at intervals cover the general surface, there is in this species on each side of the medial line of the four or five posterior segments of the (so-called) thorax, a row of small simple-pointed spines: these are closely placed together to the number of nine or ten in a semitransparent areola which surrounds the entire set; the whole arranged in the form of a short, rather abruptly curved line (Plate XVII. fig. 5).

The closely allied species we believe to be identical with *Gammarus gracilis* of Rathke, and perhaps also *G. Olivii* and *affinis* of Edwards, but which only a microscopic examination of the structure of the skin could positively determine, since they have been found at very distant habitats; the former at the Crimea, the latter at Naples. In this species, the most abundant upon our shores, the granular pavement is not so conspicuous; the walls of the cells, of which the tissue is constructed, are still apparent in their general arrangement. They form polygonal divisions caused by their mutual pressure. The small spinules, which in *G. locusta* assume an arrow-headed form, are in *G. gracilis* represented by minute sharp-pointed ones, which rise out of a socket which lies within the tissue itself, and assume the form somewhat of an hour-glass, enlarging in diameter as it does at each extremity. Besides these two appearances, there is a third, which, though not present in *G. locusta*, is a feature in the order generally. This is a series of very numerous small perforations, which in some species assume a waved appearance as they come through the tissue (Pl. XVII. fig. 4).

Without being confident in the assertion, we think that the object of these tubes is analogous to that of the pores in fish and other marine animals.

In apposition to the dissimilarity, which often is very great, between the most closely allied species of the same genus, it will not unfrequently be found that the same kind of microscopic structure is repeated in species belonging to genera widely separate.

In the genus *Gammarus*, a species on our shores, which approximates nearer to that of *G. Othonis* of Edwards than any other of which we are cognisant, and has the surface rough, though minutely so, it is sufficient to be appreciable under a lens of low power. When this is examined under a microscope of greater capability, the roughened appearance resolves into a surface irregularly covered with a number of minute projecting obtuse points. These appear to have a tendency to form into rows, the unequal length as well as distance between which are so irregularly repeated, that they appear to exist often together in clusters of greater or less importance (Pl. XVII. fig. 6).

This description of the appearance under the microscope of the dermal tissue in *G. Othonis* (?) would be equally correct of *Chelura terebrans*, which belongs to a genus which bears little or no comparative assimilation with *Gammarus*, the only appreciable difference being that the points which are scattered over the surface of each are perhaps more obtuse in *Chelura*; but even this may have some modification dependent upon the part of the animal from which it is taken, or the relative ages of either (Pl. XVII. fig. 10).

Again, in *Dexamine bispinosa* of the British seas (which in form much resembles *Amphitoë costata* of Edwards from the Isle of Bourbon), we see repeated with little variety the same microscopic characters visible in *Calliope Leachii*. In each of these the animal is covered by many small scale-like processes developed upon the surface of the dermal tissue. These, attached at one margin, are raised at the opposite, which is directed posteriorly. In *Dexamine* there are also present a few solitary small hairs or minute spinules which we have not perceived in *Calliope* (Pl. XVII. figs. 2 & 3).

The scales, broad at their attached base and rounded at the apex, resemble generally a crescent form in both *Dexamine* and *Calliope*. In *Dexamine* they appear to be more numerous and generally more minute, but it is not impossible that this supposed difference may be dependent upon age or sex.

Looking at the arrangement of the microscopic structure of the dermal tissue of this order generally, we are forcibly led to rely with considerable confidence upon its value as an important test in the diagnosis of species.

The *form and structure of the hairs* which exist on different parts of the animal, when microscopically considered, will be found to be auxiliaries of analogous character; but being not so constant in their peculiarities, are less valuable as tests of species. They not only vary in species, but differ on separate parts of the same animal. In *Sulcator arenarius* there are no less than twelve varieties.

1st. Some are plain, simple, stiff, bristle-like spines. These are common, in different degrees of strength, to the margins of the limbs generally (Pl. XVII. fig. A 1).

2nd. Are longer in general form, and are fringed on one side with a series of fine, straight teeth-like processes, assuming a rake-like character. These are attached to the maxilliped, as also another variety (Pl. XVII. fig. A 2).

3rd, Differs from the last in having the teeth bent in a curve directed to the base (fig. A 3).

4th. On the carpus of the second gnathopod (the second thoracic foot of authors), the hairs are two very distinct varieties, which appear to originate from closely approximating bases. One is long and slender, naked until the extreme point, where appear a few exquisitely delicate cilia, which give to the extremity a bulbous appearance, which can be resolved only with a 700 magnifying power (fig. A 4).

5th. The other is short, broad and flat, terminating in a point which is sharply turned upon itself; the margins of the hair are likewise furnished with a series of minute teeth pointing towards the base, ranged on each side for about two-thirds of the entire length of the hair (fig. A 5).

6th. Again, upon the same member on the propodos, we find two other forms, though decidedly moulded upon the type of the two preceding. The shorter form loses the hook-like point in a bulbous termination, and the shaft is furnished with teeth but on one edge (fig. A 6).

7th. On the appendage to the mandible a variety of this last form exists (fig. A 7).

8th. Represents the longer variety, and shows a decided increase of strength; it is slightly turned at the extremity (fig. A 8).

9th. These hairs are situated on the first gnathopod, and assimilate to No. 6 on the second in general form, but are minus the serrated margin; on one side of the extremity is a fine hair (fig. A 9).

10th, 11th, 12th are varieties of the plumose form, and are chiefly found upon the second antenna, though a few are present at several parts of the animal besides. Besides these, there are numerous modifications of a less distinct form of many of them in different positions of the animal (fig. A 10, 11, 12).

To become acquainted with the whole, so as to make the knowledge available to any practical result in the determination of species, would partake of too exclusive a study, and one that would not be commensurate to the labour entailed, if the great variety of forms were generally constant. It is not often that we meet with this obstruction.

On *Talitrus locusta* (the common shore sand-hopper).—There appears to be but a single kind of hair with but little modification of form to meet the conditions of distinct parts. They are short, stiff, blunt spines, and exhibit under the microscope a tendency to a spiral condition for about one-fourth the length of the whole from the extremity, at which distance a second, but smaller process, exists, so that the hair might be characterized as forked, but that the great inequality of the two terminations would scarcely admit the idea to be realized (Pl. XVII. fig. B). This kind of termination to the hair is by no means rare in the order. Those found in *Gammarus* are scarcely more than modifications of the same form, and not very important in their change, a circumstance which lessens the confidence in the expression of any opinion obtained from their observation.

But still the close examination of the hairs taken from positions homologically the same in different species, may not unfrequently be found an auxiliary of greater or less importance in the study of closely-allied species.

The process of moulting.—The *Amphipoda*, as all other Crustacea, renew their integumentary tissues periodically*. This remark holds equally true as regards the lining membrane of the alimentary canal, which is cast in connexion with the external skeleton. There is no appreciable difference in the habits of the animal more immediately before the casting of the skin than at any other period. It appears to swim about just the same until the hour of moulting arrives, when it seeks a place of comparative security where it may remain the desired length of time that may be necessary without fear of interruption.

The opportunities that have been most favourable for our observations have been when the animals, confined in glass jars, have occasionally chosen a position against the upright walls.

They grasp with their anterior foot or feet some fixed ground, weed, or secure material as an anchorage, resting the entire side against the glass. Here the little creature commences its labour, which appears to be one of no great discomfort, if we may judge from the small amount of disquietude with which the operation is conducted. Almost at any stage the animal has the capability of removing, if it be disturbed, to another spot out of reach.

The process appears to be the result of an internal growth of the animal, which becoming too large for the skin, it splits. This is produced at the margin where the dorsal and sternal arches of the three anterior segments of the pereion (thorax) meet, the inferior arch carrying the legs, inclusive of the coxæ (epimerals) attached to them; a fact, which identifies, we think, the relation of the (so-called) epimerals with the sternal rather than the dorsal arch.

The first of the two gnathic segments of the pereion which overrides anteriorly the cephalic ring is broken at that point from its attachment with it, and in conjunction with the two next succeeding segments it becomes a moveable lid, as it were, to the case in which the animal resides.

After some tolerable exertion, the posterior portion of the animal, together with its limbs, is withdrawn from its normal position, and ultimately becomes entirely liberated from the skin, to which the animal now remains attached by the head and the anterior members only. A few more struggles, and the creature is free of the whole of the dead exuviæ, which is left attached to its old position.

Unless disturbed, the animal, which is now extremely soft, generally rests for some time, as if exhausted, near the cast-off skeleton; should, however, there be any cause, it is perfectly capable of swimming away immediately.

In *Caprella*, Mr. Henry Goodsir (Edinburgh Philosophical Journal, 1842) remarked that the animal, before the process commenced, "lies for a considerable time languid, and to all appearance dead. At length a slight quivering takes place all over the body, attended in a short time with more violent exertions. The skin then bursts behind the head in a transverse direction, and also down the mesial line of the abdominal surface; a few more violent exertions then free the body of its old covering. After this the animal remains for a considerable time in a languid state, and is quite transparent and colourless."

The new creature is a perfect representation of the old one slightly enlarged, and, according to our own observations, every hair is produced complete; though Prof. Edwards believes that this is not the case, but that

* Mr. Bell, in his Introduction to the 'History of the British Crustacea,' has, upon the authority of Mr. Couch, stated (in a note, page lxi), "that the families in which the eyes are always sessile in their adult growth . . . . . . do not exuviate or voluntarily throw off their limbs."

they are afterwards produced. Our observations have not been pursued upon those species which are supplied with an abundant brush of hair, but still it would appear, that if the remark be correct when the hairs are few, it would lead to the same result where they are abundant. It is certainly capable of demonstration, even before moulting, for we have repeatedly observed the new hair attached to the new skin while examining specimens under the microscope, where the second layer of similarly furnished integument is distinctly visible beneath the outer; and it has always appeared to us, though contrary to anticipation, that the new materials (hairs, spines, &c.) are not developed within each corresponding hair, spine, tooth, &c., since they are visible within the integument as a second armature.

This remark is particularly verified by the teeth on the maxillæ; this may probably be here induced by their commonly forked character, which might cause an injury, should they have to be withdrawn from similarly formed organs. This is a fate that not unfrequently happens to the branchial sacs. We have seen one of these last remain within the old tunic of the cast skin, it having been torn from the parent during the process of moulting, owing to the narrow neck of the sac; but which by analogy, we may infer, is again replaced by a process of repair, common to the whole class, but which has most frequently been observed in the higher types of Crustacea.

On the reproduction of lost parts.—The power of animals to restore to its normal character a new limb or organ, is nowhere so visibly illustrated as in this great class. The manner in which it is carried into effect has been described by Dalyell, Goodsir, and others (including a short paper of our own in the 'Annals of Natural History' for 1850, as well as the British Association Reports for the same year); but these labours have chiefly been directed to the higher orders of Crustacea, among which it has been shown, that upon the infliction of an injury upon any given member, the whole limb is immediately forcibly dislocated and thrown off. This is always done at the articulation between the coxa and the next succeeding joint.

The wound that is caused by this sudden rupture of parts is naturally stanched by a thin membrane which instantly shows itself as the immediate result, and it appears not to be impossible, that its formation, which must be very sudden, may be the amputating power.

Observers have generally added as an appendage to the above curious fact in nature, that it is exceedingly fortunate that Crustacea have this power of voluntary amputation of their members at a given spot, for otherwise, enclosed as they are in a most unyielding dermal case, they must, upon being wounded, of necessity bleed to death.

In all the natural sciences there is nothing more likely to lead to error than deductions based upon negative evidence. That an animal would bleed to death under such circumstances would appear an extremely probable hypothesis; but in answer to it, the whole of the order of the *Amphipoda* appear to want the power of the dislodgement of any of the limbs, yet they do not die upon being so wounded.

If a leg be cut off, or any part injured, the wound appears shortly after to cicatrize over with a black scar; but as far as our opportunities, which have not been inconsiderable, have enabled us to judge, the member is never thrown off.

That a limb upon being lost is capable of being reproduced, is, we believe, correct, but the injured limb is not thrown off to facilitate the reproduction.

We presume, that when the animal moults the skin, the remaining portion of the injured member may be thrown off with it, and the new limb commences reproduction at that or some earlier period; but not having been enabled to state the circumstance from actual observation, we wish not to say much on the subject.

We have noticed a young limb commencing at the coxa as in the higher order, a circumstance which makes us infer that the reproduction of a lost member is always from that joint; and since it is necessary, before the completion of the new part, that the old one should be got rid of, it is thrown off at the period of moulting.

To meet with one of these animals with the limb undergoing the process of redevelopment is of very rare occurrence; so rare, that after having watched some thousands in glass tanks, we remember only having observed a single specimen which had two legs in this state.

On the auditory organs.—The upper antennæ are in Crustacea without doubt organs of hearing of a more or less imperfect nature. This, we think, has been argued to demonstration: first, by Dr. Farre, in the Philosophical Transactions for 1843, who reversed the decision of older authors, and gave satisfactory reasons for considering them as auditory organs in *Macroura*. This has been followed up by Mr. Huxley, who, in a paper in the 'Annals of Natural History' for the year 1851, supported the opinion of Dr. Farre by researches on some small exotic *Macroura*, and identified a "strongly refracting otolithe" in the anterior antennæ. And lately, in a paper communicated to the Fellows of the Linnean Society, and published in the 'Annals of Natural History' for July 1855, we have demonstrated a more elaborate and higher kind of organ in the basal joint of the same antenna in the *Brachyura*.

We may here therefore take for granted, since M. Milne-Edwards' 'Histoire des Sciences Naturelles' was published in 1840, in which he argues these to be olfactory organs, that the present state of our knowledge accepts the interpretation of the later observations on the subject *. Admitting this to be the fact, it is for us here merely to compare the upper antenna of the *Amphipoda* with the internal of the *Macroura*.

In *Amphipoda* the structure of the anterior antenna is very simple, and is generally long and slender. The second filament, which in the higher orders is commonly of equal length with the first, is in this order reduced to a rudimentary condition, or entirely wanting. When this antenna is reduced in length, it generally is increased in bulk at the base of the peduncle, as if the internal organization became more important with external decreasing extension. Examples of this are to be found in the genus *Lysianassa* (Pl. XIII. fig. 1) and *Anonyx*.

A marked exception to this is perceptible in the true *Orchestia*, where the organ is short and unimportant, approximating towards a rudimentary condition of the whole. This is a valuable fact, since it evidently is the result of certain altered circumstances which interfere with the proper development of the organ, which in *Amphipoda* generally is adapted for aquatic existence only.

Talitrus and *Orchestia* are in an intermediate position, their habits are between the aquatic and the land Crustacea, and are the nearest approach to terrestrial *Amphipoda* that we know. As their habits, so are their organs adapted. The Crustacea, which are purely terrestrial, possess no upper antennæ; those which are semiterrestrial possess them in but a rudimentary condition. They differ from the short upper antennæ of aquatic Crustacea, such as the *Lysianassidæ*. They are evidently impoverished organs, that is small, because they are not required; they ceased to grow from an arrest of pro-

* Von Siebold, in his recent 'Comparative Anatomy,' supports the opinion of Edwards, but we think not from his own actual researches so much as from the works of others.

gressive development. They are not the evidence of a more perfect structure.

This fact has not its full weight in the reasoning of Mr. Dana, when he makes the short upper antennæ evidence of a higher organized Crustacea.

The antenna is reduced in length to fulfil certain conditions: in *Talitrus*, because it is needless as an aquatic organ; in *Lysianassa* and its near allies, possibly as a more perfect one; in the *Hyperidæ*, with scarce an exception, on account of the impoverished character of the whole animal.

Talitrus and *Hyperia* are generally admitted by naturalists to rank at the opposite extremities of the order, and if generalization were to be adopted from a too narrow observation, then at whichever extremity of the order it was confined, the faulty conclusion would be enunciated which identifies a short anterior antenna as typical of an improved organization, and, on the other hand, one of a more feeble type.

The most perfectly formed anterior antenna belonging to the *Amphipoda* has always appeared to us to be that furnished with the most perfect and largest number of those appendages which we have in this paper denominated as *auditory cilia*, since they enable the organ more completely to fulfil its office. These membranous cilia we believe to be the external agents by which a sensation analogous to sound is conveyed to the consciousness of the animal. The imperfect nature of the organ is in accordance with our idea of the imperfect condition of the sensation conveyed to an animal so low in the scale of creation, conducted as it is by means of a medium so dense as water. We have never been able to observe any traces of an internal organ in this antenna, but in one or two species we have thought we detected a nerve traversing the lower side to the extremity of the peduncle in *Ægina longispina* and *Amphitoë rubricata*. This nerve terminates at the roots of the first auditory cilia, which are placed at the extremity of the peduncle, and are repeated throughout the length of the filamentary continuation, which appears to us to be a more or less extended base for the support of these delicate organisms. The number of auditory cilia belonging to the antenna bears no relative proportion to its length. They crowd together where the limb is short, as in Plate XIII. fig. 1. Upon the more lengthened member they generally are to be found, one at the further extremity of each small articulation.

These auditory cilia are to be found only on the principal filament in all the malacostracous divisions of Crustacea; the complementary appendage, however important, is never furnished with them. Their forms vary in different species, but not to any very considerable extent; occasionally they will be found, as fig. *c* in Plate XIII., to terminate with a little tooth-like point; very commonly they are seen with a kind of semiarticulation near the centre, as in *Tetromatus*; often they are quite simple, as in *Lysianassa*. But the most typical form appears to be blunt at the extremity, equal in breadth from the top to the bottom, with a sudden decrease near the centre, that gives it an articulated appearance. They are compressed longitudinally, instead of being round like hairs generally, and are extremely delicate in structure, quite transparent, and almost invisible when compared with the true hairs. They are membranous and flexible, and we should presume peculiarly appropriated for the reception of impressions of a vibratile character.

The concentration of these organisms upon a short antenna, together with the evident increase of diameter at the base of the peduncle, may be indications of an organ better adapted for the reception of sounds; but we have not been enabled to distinguish that there is consequently any relative increase of perfection in the organization of the entire animal.

Olfactory organ.—We have elsewhere* given our reasons for following the opinion of Dr. Farre, in transferring the seat of this sense to the lower or external antenna, in opposition to the opinions of Prof. Milne-Edwards, Von Siebold, and others. These, since they are too recent to be generally known, we shall here briefly recapitulate.

"The question which we have to consider is, to which sense either of the two sets of organs belongs;—whether the upper belongs to the auditory and the lower to the olfactory, as we shall endeavour to prove; or *vice versâ*, as maintained by all previous writers, except Dr. Farre and Mr. Huxley.

"We shall divide the evidences on either side under two heads; first, that which is derived from an external observation; and second, that which is derived from the internal organization.

"First then from external circumstances: An auditory apparatus is an organ furnished to an animal for one or both of two objects; first, for protection from danger; second, for the pleasure derivable from sounds. To animals so low in the scale of being as the Crustacea, placed as they are in a medium which must considerably modify its character, sound can convey little to the consciousness of the animal beyond a sense of security or danger.

"To enable this to be of the most extensive value, the auditory organ must be, and always is placed so as to be most exposed to external impressions at all periods; particularly when the animal is at rest or pre-occupied.

"Now if we look at the organ which the present state of science attributes to the sense of hearing, we find that in the most perfectly formed animals, the *Brachyura*, it is enclosed within a bony case and secured by a calcareous operculum; that it is always so in a state of rest, and only exposed when especially required. Not only is this the case throughout the order, but in some genera, as in *Corystes*, *Cancer*, &c., it is again covered by the supplying organs of the mouth.

"If we take into consideration the nature of sound, and its difference of character when conveyed under water from that of passing through air, the obtuse character of the former, which can scarcely be more than a vibratory action of particles of water, which conveys to us a very modified and imperfect idea of sound, we find it difficult to understand that the organ situated at the base of the under (internal) antenna is capable of receiving impressions of sound, enclosed as it is within and covered by a stout calcareous operculum.

"But if we view it as an organ of smell, every objection previously manifest now becomes evidence in favour of the idea. The small door, when it is raised, exposes the orifice in a direction pointing to the mouth; this also is the direction of the same organ in all the higher orders. In *Amphipoda* it is directed inwards and forwards. In every animal it is so situated, that it is impossible for any food to be conveyed into the mouth without passing under the test of this organ, and by it the animal has the power to judge the suitability of the substance as food, by raising the operculum at will, and exposing to it the hidden organ—the olfactory."

The deductions in the paper just quoted were the result of researches chiefly made on the *Brachyura*. In the *Amphipoda*, the homologue of the above organ, which we maintain is adapted for smelling, is to be found in the form of a small spine or denticle at the inferior side of the second antenna.

This denticle is so constant, that its absence is a thing of note, as for instance in the almost terrestrial genus of *Orchestia*; probably the result of an adaptation of the internal organ to meet a more rarefied atmosphere.

This organ appears to be developed from the first and second joints of the

* Annals of Natural History, July 1855.

peduncle; for the two appear to be so closely associated, that it is impossible to say to which it more immediately belongs. From analogy with the higher types, we should infer the first, though probably the two combine to increase the efficiency of the organ by their concentration.

In the freshwater species of *Gammarus*, the organ appears rather larger and more characteristic in form. It is from this species we shall give our description of the organ.

The first joint of the antenna is enlarged into a chamber of a globose form (Pl. XIV. fig. 4 *a*): this is received into a corresponding notch of the cephalic ring (fig. 3). From the globular chamber, which appears to be the protecting walls of an internal organ of more delicate contrivance, there proceeds a large tooth-like process (*b*), which in this Report we have called the *olfactory denticle*. It differs in length and breadth in different species, but is a very constant appendage. This process is open at the extremity (*c*), through which a tube projects (*d*), which latter is either open, or protected by a membrane too delicate to be observed, but which, from analogy with the higher orders, we are induced to believe may be the case. It is not always that the tube projects through the aperture at the extremity of the denticle; occasionally it falls short, as in *Isæa* (fig. 1); but this is merely a variety depending upon species.

The tube appears to be cylindrical, and continues internally with parallel walls to about half the length of the tooth itself, when it suddenly converges to a point, which is open, since it is entered by what appears to be a nerve, which either itself terminates in or supplies with sensibility a sharp tongue-like process (*f*), which is enclosed within the cavity of the tube-like canal. From the base of this small organ the supposed nerve is traceable in a waving line to a small bulbous origin (*g*), situated at the base of the olfactory denticle at its point of connexion with the enlarged chamber. Beyond this probable ganglion the closest investigation has not enabled us to see any further trace of the nerve.

This organ, with but little variation of external form, is to be met with in almost every species, even including those where the whole antenna is produced in the form attributable to the character of legs, and used as such in climbing over irregular protuberances of the ground.

The species in which the organ in its external form does not exist, are the *Talitri*, *Orchestiæ*, and the *Hyperiæ*, together with a species of *Gammarus*, which we believe hitherto to be undescribed; we call it in our list *Gammarus elegans*, on account of the general beauty of the form and colouring of the only specimen we have yet taken*. The lower antenna in this species is supplied with a peculiar set of organs, similar to those which have been described by Prof. Edwards in his species *G. ornatus*. Commencing on the last joint of the peduncle to the extremity of the long filament, there is, at gradually increasing intervals, a series of small membranous polyp-like bodies: they are closed sacs, and require but a low power of the microscope to perceive them. Those described by Edwards are fringed with a slightly ciliated border, and belong to a North American species, which differs in other essential respects from our British form. To assign any peculiar use to these organisms came not within the conception of their original observer, and we can only point to this solitary instance of their being present on the olfactory antenna, where the organ of the sense peculiar to it is either absent or reduced to a rudimentary character: but a more extended opportunity of observation is necessary before we can attempt to pronounce this condition constant (Pl. XIV. figs. 5 & 5 *a*).

* This may be the true reason why the olfactory denticle has not been observed: we were afraid of injuring the specimen.

In *Orchestia*, as previously observed, the absence of the olfactory denticle is probably the result of altered internal conditions of the organ necessary to meet the peculiar change of circumstances into air from water, in which the *Amphipoda* normally reside.

The denticle, when present, is situated slightly in advance of the mouth, and nothing can be eaten that does not pass the ordeal of the olfactory organs, for such we do not hesitate to call them.

Taste.—The sense of the enjoyment of food, even in the highest types of the animal kingdom, is not the result of the power of any especial organ. The nerves which communicate the idea are developed over most of the internal surface of the mouth, and it is only the consciousness of taste that demonstrates their position and use. The probability from analogy is, that the sensation is manifest to creatures low in the animal scale in a similar manner, and is rather a faculty peculiar to the mouth in general, than the result of any especial combination directed to a given part.

In *Sulcator arenarius,* and only in that species, have we observed what may possibly be an especial organ of taste. There is a large protuberance upon the first maxilla. It has a somewhat glandular appearance, and is the result of cell growth; these cells are large and nucleated. We have failed to observe the organ, or anything analogous in the same or a similar position, in any of the more common and numerous forms of *Amphipoda* that we have examined. It can scarcely be looked upon in the light of a salivary organ, although its component cells possess all the characteristics of those belonging to a secreting gland, since its position upon the maxilla, being external to the mandibles, forbids the idea. The purpose of this organ (if it be one) will require more extended and systematic observations ere it can be resolved from its present enigmatical character (Pl. XV. fig. 4 *a*).

The Prima Via.—The œsophagus leads, as in all Crustacea, abruptly from the mouth to the stomach; it is extremely short and is directed upwards, inclining rather forwards than otherwise, so that the stomach is almost entirely within the cephalic ring in the *Amphipoda.*

Just within the anterior opening of the stomach are two rake-like organs (Pl. XIX. fig. 1 *a*, *a*); the rows of teeth form themselves on each side into a convex line, the teeth being a little curved, the lower or anterior ones mostly so. The apparatus directs its teeth inwards and backwards, so that the food may with ease pass in, but cannot again return. The teeth on each side appear to be antagonistic sets, which probably tear and masticate the food as it enters into the stomach.

Behind this masticating apparatus there exist four simple leaf-like plates fringed with long and powerful cilia, placed in pairs (*bb*, *cc*), one anteriorly and the other posteriorly situated in the stomach; immediately above the second or posterior pair, apparently in a chamber of its own, is a gizzard-like organ (*d*). This so-called gizzard consists of several closely-packed rows of fine short strong hairs, the whole formed into the shape, when displayed, of an inverted heart with the apex removed, and the reversed section added to the base; the walls of the cavity in which the gizzard exists is lined with numerous but small hairs: the whole apparatus appears to be placed out of the direct line of continuation between the œsophagus and the alimentary canal. Posterior to the gizzard-like organ, there exists in some, but we are not certain that it is common to all the *Amphipoda*, a long *cæca* or *cul de sac* (*e*, *e*) on each side of the posterior opening of the stomach. These are delicate prolongations of the wall of the stomach, and gradually become narrower towards their extremity. They probably supply the stomach with a gastric juice. Still more posteriorly, at the point where the stomach converges and unites with the alimentary canal, on the inferior surface, it is united with the liver.

From the stomach, the alimentary tube is continued in a direct line to the anal extremity. To this general law we know of but one exception, and that upon the authority of Professor Allman, who states that in *Chelura terebrans* the alimentary canal is so arranged as to shut one part within another to admit of the head being projected forwards, that the animal may eat its way into the wood.

In a few species the alimentary tube is continued beyond the posterior limits of the calcareous tissue of the animal, and is furnished with a slightly pectinated edge.

The most constant condition is, that the anus shall coterminate with the last segment, and is there closed by a set of transverse muscles which probably fulfil the office of a sphincter (Pl. XX. fig. 1 *c*).

The structure of the walls of the canal appears to be a membrane possessing a fibrous character which stripes it in a longitudinal direction (Pl. XIX. fig. 5). Transverse lines of a finer appearance are also perceptible (fig. 6); and the general appearance of the whole is that of a passage surrounded with elastic walls.

The stomach is retained in its position; first, by being supported upon flat calcareous plates (Pl. XII. figs. 4 O & 5), processes of the dorsal part of the segment which carries the maxillæ. These processes are flattened to receive the organ, which is further retained in its position by a calcareous continuation on each side. Besides, there are several muscles, some of which are attached to the upper external surface and retain it anteriorly, while others are attached to the under surface and hold it posteriorly in position (Pl. XIX. fig. 2, *f* & *g*).

The Liver appears to be among the most important of the viscera, if we may judge from its relative size. It uniformly, as far as our experience teaches us, consists of four long simple sacs filled with biliary cells, the contents of which are yellow in colour (Pl. XIX. figs. 3 *p*). These separate sacs unite together at their anterior extremity into a single short biliary duct, which opens into the intestinal tube on the under aspect, immediately where it leaves the stomach.

Urinary organs.—About two-thirds the distance from the stomach to the anal aperture, two long cylindrical appendages, closed at the free extremity, communicate laterally upon the upper side with the intestinal tube (Pl. XX. fig. 2). These appendages are more important in appearance in some species of *Amphipoda* than in others; but as far as our experience guides, they are universally present both in male and female, as also in the immature animal. In the younger forms they are rudimentary, as shown in fig. 4, taken from *Amphitoë*; but are scarcely more so than those found in the adult *Gammarus grossimanus*, as shown in fig. 3 of the same Plate.

Immediately posterior to the communication of this organ with the alimentary canal are a series of muscular fibres transversely lying across the latter (Pl. XIX. fig. 1 *b*); they strongly assimilate both in form and arrangement with those which we have already mentioned as being sphincter muscles, to the terminal orifice of the alimentary tube. The position which this second set of muscles holds is at the immediate point of communication between the two organs, and the general appearance would also induce us to believe that their object is to fulfil a similar office and keep compressed the efferent orifice. In fact they act the part of sphincter muscles to the urinary organ.

Although we name these the urinary organs, yet it is without perfect assurance that we can arrive at the conclusion of their veritable purpose. But from their general position and structure, their constant presence both in male and female, old as well as young, together with the form of the entire apparatus, we are induced to believe them to be a simple form of urinary organ.

The contents, under a one-fifth power of the microscope, are resolved into small round cells, containing a nucleus of granular material (Pl. XIX. fig. 6). These cells are closely packed together, but not so firmly as to lose their original form; and the whole are confined within the walls of the organ, which appear to be very stout, the external surface of which is slightly notched (fig. 5) at tolerably regular distances, as if the organ had the power of contraction and expansion. Both the organs (if there are always two, of which we are not certain, in every species, since we have not clearly demonstrated them, except in *Sulcator*) (fig. 2) lie so closely together, as to appear like one; but in the genus *Sulcator* we have displayed them both by dissection. They lie their full length along about one-third of the upper aspect of the alimentary canal, and towards the posterior extremity make a sudden turn, and directly after connect themselves with the alimentary canal (fig. 1). The appearance of the structure at this bend is of a much more robust character than at any other point of the organ.

The Vascular System.—At the anterior portion of the alimentary canal, and placed above it, lies the cardiac vessel or heart (Pl. XXII. fig. 3 *a*). It is a long simple organ more like an aorta than a heart, reaching from the first to the last segment of the pereion (or thorax), and does not extend, as asserted in the 'Histoire des Crustacés' (vol. i. p. 98), "through the whole length of the abdomen," as is the case, upon the same authority, in the *Stomapoda*. The superior wall is suspended by a series of attachments at the centre of each successive segment, which gives it a festooned appearance through the whole length of its upper surface. The walls of the organ are of a fibrous character, arranged diagonally to the vision under the microscope, the result we believe of a spiral arrangement in the general structure of the walls. The whole possesses an elastic nature, and a persistent pulsation is carried on, causing the festoon on the upper surface to rise and fall with each successive throb.

Corresponding with the centre of each segment there is an aperture in the heart into which passes the blood, being propelled by successive jerks (Pl. XXII. fig. 3 *c*, *c*, *c*). The (so-called) blood-corpuscles are very discernible, and by this means the course of the circulation is not difficult to be traced. Though the corpuscles travel in a continuous current, yet we have never been able to distinguish that this channel is bounded by walls, in fact that there are any true blood-vessels. That none exist we think may be strongly inferred from the fact elucidated by close and continued observation of the circulation, where two currents, an arterial and a venous, travel in close proximity to each other; an occasional corpuscle from the arterial may be seen to pass over to the venous without traversing the greater circuit followed by the others.

An arterial current passes through the whole length of the animal immediately above the alimentary canal, and the great venous course returns along the dorsal centre; at the commencement of the pereion (thorax) the current appears to descend, and becomes confused to observation with the arterial channel. (Vide diagram, Pl. XXII. fig. 3.)

The legs are nourished by a single arterial current and its venous return; in the broad plates of the coxæ the arterial course passes down through the centre, where it diverges and returns as two venous currents, the one on the anterior, the other on the posterior margin. Near this point are situated the branchial organs, where the blood, which is much divided and exposed to aëration, goes, we believe, direct to the heart, and then, without returning again to these organs, passes on its way, carrying oxygen to the general system.

The Branchiæ.—These are by no means the simple sacs that authors have universally described them. They are situated upon the inner surface of the coxæ of the leg, and assume the form of leaf-like plates on each side of the sternum, and are attached to every leg except the first in females, and generally the last in males, though in *Gammarus* we have seen them present in the male as well as the female, on the seventh, as shown in Pl. XXI. fig. 3.

The arterial course passes down on the side nearest the heart, and divides itself as it proceeds along the internal labyrinth of the organ into many streams, and passes out of the vesicle by an efferent course on the side opposite to that on which it entered.

The corpuscles never increase beyond one deep. Thus each of these supposed oxygen carriers is brought into immediate contact with the thin walls, which alone separate them from external atmospheric influences. The branchiæ homologize with the same organs in the higher orders of Crustacea, and each may be viewed in the light of a solitary plate of one of those more compound organs. In fact they bear an extremely close resemblance to the branchiæ of the *Brachyura* in the larval condition, before they assume the foliaceous appearance of the perfect organ (Pl. XVIII. fig. 10).

The great difference in the general character appears to be derived mostly from the appearance which the organs in the higher types assume of a resemblance to an internal position; but this is a condition of appearance only, as shown in an earlier portion of this paper; the branchiæ are overcapped by the monstrous production of the anterior cephalic segments, a peculiarity which is not carried out in the Amphipodous order; consequently the branchiæ are external and pendent in the water, and it is for their greater protection that the coxæ are developed into large scaliform plates.

The internal structure of the branchial organs appears to be produced by a thickening of a fibrous tissue in contact with the internal surface of the walls of the organ (Pl. XVIII. fig. 7). This appears to be carried out in patches of an irregular form, but which correspond in their arrangement with one another. These patches are thickest at their centre and thin out towards their edges: the result is that a channel is left between each. All the channels so formed are connected together throughout the whole organ, and exhibit a continuous labyrinth in which the blood circulates in many small streams (fig. 8).

Should the animal become feeble, a gradual accumulation of corpuscles may be discerned in different parts of the gills, mostly out of reach of the stronger currents, which latter, as the vitality of the animal diminishes, can be observed to lessen in force until it is propelled only by jerks, coexistent with every pulsation of the heart; and at length a throbbing without any progression of the corpuscles appears as the last effort of decaying circulation.

The external form of the organ varies but little: in *Talitrus* (Pl. XVIII. fig. 3) there appears a second of smaller dimensions, originating from a common base, the stalks being separated. Somewhat similar are they in the branchiæ of *Sulcator arenarius* (fig. 1), and would appear as if it were an effort of nature to make a step towards the more foliaceous organs of the higher types. In the *Aberrantia* we find that *Caprella Pennantii* (for in this group, except in the genus *Proto*, there are but two sets attached to the third and fourth segment of the pereion (thorax)) has the anterior branchia round and much larger than the posterior, which is more cylindrical in form.

In *Ægina* they are long and slender, and furnished on the outer side of the neck with a small articulated scale, the rudiment of the undeveloped leg (fig. 6).

Organs of Generation (*male*).—The dissection of these organs requires much care; the most distinct that we have been enabled to make out were in a specimen of *Sulcator arenarius*, sent us by our most valued correspondent, the Rev. G. Gordon, taken in Moray Frith. This specimen was so exquisitely transparent, that we could readily detect the white patch of the testes with unassisted vision; and by cautious dissection under the microscope, we were enabled to trace the connexion between them and the external organs*.

The testicles are large, opake, oblong organs, being in breadth about equal to half their length; they are situated on the dorsal aspect, immediately beneath the dermal tissues, occupying a position under the sixth and seventh segments of the pereion (thorax) (Pl. XXI. fig. 1).

From the posterior extremity of each, deflecting one to the right, the other to the left, a vas deferens proceeds towards and enters into the first joint of the seventh pair of legs (figs. 2 and 3), and again passes out and terminates in an external penis; but whether intromittent or not we have hitherto failed to discover, though we believe it is not. We have had *Gammarus gracilis* long in keeping, and watched them in their habits much; but have never detected any communication between the sexes which could admit of a direct passage of the penis into the vulva, which latter organ we have not yet discovered in the normal *Amphipoda*.

The male appears to grasp the opposite sex by one of its strong subcheliform gnathopoda, by the insertion of the claws beneath the anterior edge of the first segment of the pereion (thorax), whilst another is inserted beneath the posterior margin of the fourth or fifth. Thus grasping the female by the back, it draws it into immediate contact with the ventral surface of itself. In this attitude, more or less firmly compressed, they swim and rest alternately for days, or perhaps, as we believe, a very much longer period, without any apparent closer communication.

If the two be driven asunder by any fear of danger, as has been performed by us for the value of the observation, the female seeks a place of shelter, while the male swims more actively about; and we have noticed, that should it after a few moments swim within a little distance of its late mate, it instantly becomes aware of the circumstance, and having passed the spot, will turn abruptly back, seek her out, and seize her with avidity from amidst several others, and immediately after securing, strike her with two or three strong lashes of the tail. The female rolling herself up in fear is so carried off by her more powerful mate.

This contact between the sexes is either occasionally repeated or may last through the whole period of incubation, as we have frequently taken them coupled in this manner, even when the matured young have been sufficiently advanced as to leave the care of the parent. We are induced from this fact to believe, that a series of broods are producible from the same parents during the year, and that the erotic state of the female may exist during the incubation of any previous brood.

The penis is a soft membranous tube, the external continuation of the vas deferens, with the probable capability of erection (Pl. XXI. figs. 1, 2, 3 *a*). The orifice occupies but scarcely half of the diameter of the extremity of the tube, and most probably has the power of closing itself voluntarily. This remark is true both in *Gammarus* and *Sulcator*, in which latter the organ is

* The observations of De Siebold on this organ chiefly relate to the *Isopoda*.

considerably longer, and terminates with a simple opening near the centre of the extremity of the tube (fig. 2 *a*). In *Gammarus* (fig. 3 *a*) the orifice is on one side of the terminal point, and furnished with a small bundle of minute hairs.

The spermatozoa are long simple hair-like bodies, and bear a general resemblance to those found in the *Cirripedia*; in *Sulcator* they have their largest diameter at one end and the smallest at the other, but there is no decided enlargement of one part over the other to give it the tadpole resemblance of the typical form of these organisms. In *Gammarus*, the largest part*, if one is larger than the other, is a little on one side of the centre, with the smallest diameter equally at each extremity†.

In the *Aberrantia*, a group recognized under the generally-accepted synonym of *Læmodipoda*, the male organs are of a more powerful character, and connected in *Caprella* with the coxæ of the last pair of thoracic legs, which in this group are all anchylosed with the segment from which they originate (Pl. XXI. fig. 4 *a*).

In the closely allied genus *Proto*, the pleon (abdomen), though rudimentary, is not so entirely obsolete; similar appendages to those which we have considered male organs in *Caprella* exist, four in number, but these homologize with the pleopoda of the anterior pleon in the normal type of *Amphipoda*.

This fact can scarcely interfere with the adaptation of the members as intromittent organs, since in the higher order of the *Brachyura* the vas deferens is known to pass directly into one of the false feet, modified for a similar purpose. The observations on this family are further supported by those of M. Rousel de Vauzeme, on *Cyamus ovalis*‡, in which the organs are situated analogous to those of *Caprella*.

Organs of Reproduction (*female*).—If we found that to become acquainted with these organs in the male required much care, those of the female demand it still more, a circumstance which will account for the incompletion of all their details with this Report; but we feel assured that which we here state may be relied upon as correct as far as it goes.

In the normal type of the *Amphipoda*, hitherto we have failed to discover the vulvæ, but infer its place from the fact of their constant position in all the higher forms of Crustacea, on the coxæ of that pair of the pereipoda or walking legs, attached to the fifth segment of the pereion; and we are induced to assign them an analogous position. In the *Brachyura* they are generally described by authors as perforations in the sternum; so they appear also in the abnormal *Amphipoda* (*Caprella*): in both these cases, as has been proved, the coxæ are fused with their supporting segments. In *Homarus*, &c., where the coxæ are free, the vulvæ are seen in their normal position, which we believe to be homologically constant in Crustacea; and those in the *Amphipoda*, probably being only oviducts in their adaptation, have escaped our observation from some slight obstruction to our plan of inquiry.

* We have observed minute objects like fat-globules attached to these thread-like organs with which they were in contact, or else form a part of the structure; a few in fig. 5 are drawn with the spots attached.

† The description given by Von Siebold in his 'Anatomie Comparée,' p. 472, § 290, agrees generally with the forms here alluded to. He says, moreover, that they are very similar in *Mysis* and the *Isopoda*. This statement is made by him on the authority of observations on *Mysis*, *Oniscus*, *Porcellio*, *Idothea*, and *Gammarus* (Von Siebold, Müller's Archives, 1836); and Kölliker has observed the same, but states them to be rigid, and not in a figure of 8, as observed by Siebold in *Iphimedia obesa* and *Hyperia medusaria*, where they are slightly enlarged and a little bent at one extremity.

‡ Ann. des Sciences Nat. 1834.

In *Caprella Pennantii* two distinct circular orifices, situated side by side, as in the highest types, are visible in the calcareous ventral aspect of the fifth segment. This is also confirmed by Rousel de Vauzeme in his observations on *Cyamus ovalis*, except the organs which he appears to raise on small prominences (Pl. XIII. fig. 17 *a,a*, Ann. des Sc. Nat. 1834). The position of these organs is very readily distinguishable, even in the dried animal, and contradicts the statement of Mr. H. Goodsir, that they are placed one before the other in the middle of the ventral region (Edin. Phil. Journ. 1842), Pl. XXI. fig. 8.

The internal organs consist of two sets of ovaries placed one on each side, but are not the simple tubes described by Von Siebold; but as that author's information consists chiefly of the results of Rathke, Brandt and Müller, who mostly pursued their researches upon the *Isopoda*, it may be that still we are both correct in the individual instances. Rousel de Vauzeme figures them in *Cyamus ovalis* of the same simple character as described by Siebold, terminating each posteriorly in a short oviduct.

The ovaries in *Gammarus* appeared to us to consist of four or five sac-like organs, narrowing each towards their attachment with a canal into which they all empty themselves in succession, the largest being the most distant from the extremity approximating the vulva. One of these sets was found upon each side of the alimentary canal, and appeared to be enclosed within a common sac; that is, we observed a transparency around the whole organ which induced us so to interpret the appearance, though we were unable to dissect the organ out, or trace it in continuation with the as yet to us undiscovered vulva.

It is not certain at what time the impregnation of the ovum takes place by the fertilizing spermatozoa, and it is only conjecture that induces us to assume it must be as the former escapes from the oviduct. Thus, if we are correct in our deduction from negative evidence, that an intromission of the male organs does not take place, then we must conclude that the male emission must escape into the surrounding medium, and that of the many thousand active organisms, some are attracted by the force of the continued currents, induced by the swimming feet, into the incubatory pouch, where they are brought into contact with and impregnate the recently deposited ovum, which after fertilization continues in this position to be cherished until after the larva quits the egg. The supposition that impregnation is an external act is supported by the observations of Von Siebold (p. 472 of the work already quoted), that the spermatozoa continue rolled into a figure of 8 until they come into contact with the water.

The Incubatory Pouch is the result of the folding over of several lamelliform plates, generally fringed with hairs. One of these is developed upon the inner side of each of the two pairs of gnathopoda and the two anterior pereipoda (or four anterior pairs of thoracic feet). These plates overlie each other in a compact form, and securely protect the eggs or the immature young from external accidents (Pl. XVIII. fig. 11).

This lamelliform appendage, which is called the palpe by M. Milne-Edwards, is, according to Von Siebold (p. 476), developed at the "époque du rut," and afterwards again disappears. This we have not been able to verify, since we have frequently taken the female at all periods of the year with these appendages fully developed, but do not recollect ever having seen them in a half-formed state. We have never observed them present on the young animal, so that probably they may be produced as the animal arrives towards the era of female development. But we are inclined to doubt, when once developed, that they ever again disappear except as the result of accident.

On the Development of the Young.—The length of time between the epoch of the deposit of the ovum to that of the emancipation of the young animal from the care of the parent, has not, as far as we are aware, been ascertained, but from parallel circumstances in *Asellus*, among the *Isopoda* it appears to last from about a month to six weeks.

At first the egg is perfectly round in form; it shortly increases in length, assuming a larger proportion at one extremity than the other; it is now that the young animal is seen under development, and indistinct segments are observable. The wall of the ovum is formed of an elastic membrane which corresponds to the movement of the internal embryo.

It is probable, that about the middle of the period of incubation, the young animal quits the egg, for we have constantly taken them from the pouch, bearing an embryonic character without being closed in their egg-case. The larva at this period is very immature and covered in a general tunic, which, apparently without having any absolute vital connexion with the animal more than the original egg-case had to the embryo, adapts itself in form to the whole creature, and fulfils the duty of a protective tissue. This probably is shed more than once, as we perceive that as the animal increases in size and completeness of form, so the tunic corresponds in its general adaptation; and at last the larva frees itself from this case and strengthens in its own development, but appears not to quit the care of the parent immediately. We have often observed that the young escape from the mother if she be taken or alarmed; from the active state of their existence at this time, they appear as if they had long since been capable of so acting if they had preferred or circumstances required it. Repeatedly observing this fact, we have been induced to believe that they had the power, and used it, of quitting the parent occasionally, and either returned to the pouch again, or else being free, continued more or less perfectly under her protection. This trace of parental affection receives support from the observation of Mr. Henry Goodsir*, who "on one occasion, while examining a female *Caprella* under the microscope, found that her body was thickly covered with young ones; they were firmly attached to her by means of their posterior feet, and were resting in an erect posture, waving about their long antennæ with great activity." But although the resemblance to the parent is very considerable, yet it is by no means complete, and it is probable that several moults are undergone before the perfect development of the animal is matured. The value of the relative difference is important, since the observation of the same animal at different stages of its existence might otherwise lead to the misinterpretation of the value of species.

When the young of *Gammarus gracilis* first appears as an animal, dependent upon its own resources, there is no very decided contrast between the articulations of the peduncle of the antenna and those which pertain to the filament. The latter itself is shorter, consisting of five articulations only, than in the mother, where there are twenty-nine; and we counted thirty-five in a male of the same species; again, in the inferior antenna there are but three joints to the filament, whilst in the adult male and female sixteen are developed. This relative difference is likewise constant in the small filamentary appendage of the upper antenna, which in the larva has but two segments of an unequal length; in the adult there are six or more.

Again, in the structure of the eye we see the same gradual increase still goes on after the young has become free. The facets, or rather lenses, which are seen beneath the integument of the animal (for we consider that the eye has no especial dermal covering peculiar to itself in *Amphipoda*),

* Edinb. Phil. Journ. 1842.

are in the young from ten to twelve in number, whereas in the adult from sixty to eighty can be counted, and the cornea assumes a deeper tint; being crimson in the larva, it becomes purple or almost black in the adult.

The young are generally of a more or less deep orange colour; in some species they are cornuous and transparent; and in the development are generally less marked than the adult.

The large hand in *Orchestia* holds in the larva a nearer contrast to that of the female than to the larger claw of the male; it is therefore extremely probable that this organ likewise increases in growth; a fact also remarked by Rathke*, regarding the warty development of the posterior leg of the same animal which still goes on with increasing age.

In *Hyperia* the larva bears so little resemblance to the parent, that it has been pronounced by Edwards, who first observed the fact, and Mr. Gosse, to be a metamorphosis; but since, even in the higher types, the immense variety of change from the *Zoë* to the adult animal is but the result of subordinate becoming more important parts, together with development of others not yet present, and therefore hardly acceptable under the signification of metamorphosis, as understood in true Insecta; we can scarcely subscribe to the great alteration of form as a metamorphosis in *Hyperia*, which is one of degree only, and of which we shall give a figure in the forthcoming 'British Edriophthalma.'

On the Nervous System.—This part of the subject has been attended to with more care than perhaps any other part of the animal, by MM. Audouin and Edwards, in a memoir published by them on the nervous system of Crustacea generally.

To this paper, which has been made the standard of all authors, we shall now refer the reader; and in this Report only draw attention to particular details of more or less importance, which we have noticed from actual observation in dissections made upon *Talitrus locusta*, and which are given in our figures of the nervous system of that Amphipod in Pl. XXII. accompanying this Report.

The scheme of the arrangement is peculiarly annular, perhaps typically crustacean; a ganglion corresponds to every segment of the animal, each being united to the other by two cords, which correspond, but are not connected with each other. From each ganglion on the right and left, a double branch is given off; the one passes to the legs, the other probably to the branchial organs. In the male, the ganglion corresponding with the seventh segment of the pereion (thorax), which supports the male organs, appears a little larger than the others. From the cords intermediate between the ganglia originates on the external side of each a corresponding nervous thread, which again divides into two, and probably supplies the internal viscera of the animal. These threads have not been recorded in the memoir quoted as belonging to the *Amphipoda*, but analogous ones are figured in the 'Histoire des Crustacés,' pl. 11. figs. 3, 4, as belonging to the *Stomapoda*. But a more important variation in the nervous system of the *Amphipoda* exists in the arrangement of that part which belongs to the cephalic region. The first ganglion (Plate XXII. fig. 2 E) of the pereion (thorax) rests upon the sternal portion of its own segment, from which anteriorly a sudden depression takes place to the infra-œsophageal ganglion (B), which lies beneath a calcareous arch (O), which earlier in this paper has been described as being the dorsal aspect of the three segments, which fused together support the maxillæ and maxilliped.

From the infra-œsophageal ganglion several nerves originate to supply

* Faunen de Crim. Phil. Trans. St. Petersburg.

the attendant appendages of the mouth, and two more important ones are directed anteriorly to the supra-œsophageal or cephalic ganglion, which last we have not satisfactorily made out, although we have traced the nervous cord almost to its connexion with it, that is, up to the anterior or facial wall of the head.

The probability is, that there is no very great amount of difference from that which is figured by Edwards and Audouin as belonging to the *Amphipoda* proper, or as given by Rouzel de Vauzeme, as observed in the aberrant genus of *Cyamus*.

Any observations, either on the generalization or geographical distribution of the order, we shall reserve until we furnish the second part of the Report 'On the British *Isopoda*,' and here only remark that our experience induces us to consider the *Amphipoda*, inclusive of the aberrant group, as a modification of the great Crustacean type, as exemplified in the *Macroura*, rather than as possessing a perfectly distinct characteristic, as asserted by Mr. Dana. In this conclusion we approximate that already arrived at by Edwards in his 'Observations on the Classification of Crustacea' (Ann. des Sci. Nat. vol. xviii. n. s. p. 121). But he includes in his remarks the *Isopoda* and the *Pycnogonides*, with which in this Report we have nothing to do.

In the accompanying Table the species are arranged according to order. Those which are in italics have never been previously recorded as British. Those marked with an asterisk, are species which we have not examined, and record upon the authority of previous authors.

Order I. AMPHIPODA.

Group A. NORMALIA.

Division A.A. GAMMARINA.

Subdivision A.A.a. *Vagantia*.

Tribe *a.a.* SALTATORIA.

Family **Orchestidæ**.

Genus.	Author.	Species.	Author.
Talitrus	Bosc.	locusta	Latr.
Orchestia	Leach.........	littorea	Leach.
		Deshayesii	Audouin.
Allorchestes ..	Dana	*Danai*	mihi.
		imbricatus	mihi.
Galanthis	mihi	*Lubbockiana* ..	mihi.

Tribe *b.b.* NATATORIA.

Family **Gammaridæ**.

Subfamily I. Stegocephalides.

Montagua	mihi	monoculoides. .	Montagu.
		marinus......	mihi.
		pollexianus ..	mihi.
		dubius	mihi.

Subfamily 2. Lysianassades.

Genus.	Author.	Species.	Author.
Lysianassa	Edwards	*Costæ*	Edwards.
		Audouiniana	mihi.
		Chausica	Edwards.
Scopelocheirus	mihi	*breviatus*	mihi.
Anonyx	Kroyer	*Edwardsii*	Kroyer.
		minutus	Kroyer.
		ampulla	Kroyer.
		Holbolli	Kroyer.
		denticulatus	mihi.
Amanonyx	mihi	*Guerinianus*	mihi.

Subfamily 3. Tetromatides.

Tetromatus	mihi	*typicus*	mihi.
		Bellianus	mihi.

Subfamily 4. Pontoporeides.

Westwoodea	mihi	*cæculus*	mihi.
		carinatus	mihi.
Phoxus	Kroyer	*Kroyerii*	mihi.
		plumosus.	
Sulcator	mihi	arenarius	mihi.

Subfamily 5. Gammarides.

Darwinea	mihi	*compressus*	mihi.
Iphimedia	Rathke	*obesa*	Rathke.
Acanthonotus?	Owen	*Owenii*	mihi.
Dexamine	Leach	spinosa	Montagu.
		bispinosa	mihi.
		Gordoniana	mihi.
		fucicola	Edwards.
Calliope	Leach (MS.)	*Leachii*	mihi.
Isæa	Edwards	*Montagui*	Edwards.
Lembos	mihi	*Cambriensis*	mihi.
		Damnoniensis	mihi.
		versiculatus	mihi.
		Websterii	mihi.
Lonchomerus	mihi	*gracilis*	mihi.
Eurystheus	mihi	*tridentatus*	mihi.
Amathia	Rathke	*carinatus*	Rathke.
Gammarus	Fabr.	*Sabinii*	Leach.
		carinatus?	Johnston.
		locusta	Fabr.
		fluviatilis *	Edwards.
		pulex	Fabr.
		gracilis	Rathke.
		camptolops	Leach.
		palmatus	Montagu.
		marinus	Leach.
		longimanus	Montagu.
		brevicaudatus	Edwards.
		grossimanus	Montagu.
		elegans	mihi.

Genus.	Author.	Species.	Author.
Gammarus ..	Fabr.........	*Othonis*?	Edwards.
		maculatus? ..	Johnston.
		subterraneus*.	Leach.
Niphargus* ..	Schiödte	Stygius*......	Westwood.
Thersites	mihi	*Guilliamsonia*	mihi.
		pelagica	mihi.

Subfamily 6. LEUCOTHOIDES.

Leucothoë	Leach	articulosa	Leach.

Subdivision B.B.b. *Domicola.*

Family 1. Corophiidæ.

Division A. NIDIFICA.

Subfamily PODOCERIDES.

Pleonexes	mihi	*Gammaroides*..	mihi.
Amphitoë	Leach	rubricata	Montagu.
		littorina	mihi (punctata, Johnston).
Sunamphitoë..	mihi	*hamulus*......	mihi.
		conformatus ..	mihi.
Podocerus	Leach	pulchellus	Edwards.
		pelagicus	Edwards.
		punctatus	Edwards.
		variegatus	Leach.
		falcatus	Montagu.

Division B. TUBIFICA.

Subfamily 1. CERAPIDES.

Erichthoneus..	....	difformis.	
Siphonocetus ..	Kroyer	*Kroyeranus* ..	mihi.
		crassicornis ..	mihi.
		dubius	mihi.

Subfamily 2. COROPHIIDES.

Cyrtophium ..	Dana	*Darwinii*	mihi.
Corophium ...	Latr.	longicorne	Latr.

Family Cheluridæ.

Chelura.......	Philippi	terebrans	Philippi.

Division B.B. HYPERINA.

Family 1. Hyperidæ.

Hyperia......	Latr.	Galba........	Montagu.
		oblivia.	Edwards.
Læstrigonus*..	Edwards	*Fabreii*	Edwards.

Family 2. Phronomidæ.

Phronoma	Latr.	sedentaria	Latr.

Family 3. Typhidæ (? British).

Typhis	Risso........	nolens*	Johnston.

Group B. ABERRANTIA.

Family Caprellidæ.

Genus.	Author.	Species.	Author.
Proto........	Leach	pedata	Leach.
		Goodsirii	mihi.
Ægina	Kroyer	*longispina*	Kroyer.
Caprella......	Lamarck	linearis	Latr.
		lævis*	Goodsir.
		acanthifera....	Leach.
		acutifrons	Desm.
		phasma	Latr.
		tuberculata* ..	Goodsir.
		lobata*	Müller.
		Pennantii	Leach.
Cyamus	Latr.	ceti*	Linnæus.
		ovalis*	Rouss.
		gracilis*	Rouss.
		gracilis*	Gosse.

Reference to Drawings.

PLATE XII.

Fig. 1. Head of *Talitrus locusta*, frontal aspect.
Fig. 2. Head of ditto, lateral aspect.
Fig. 3. Head of ditto, posterior.
Fig. 4. Head of ditto, interior labial.
A. Inferior antennal segment.
B. Mandibular segment.
C. Epistome or inferior portion of B.
D. Upper division of labium.
E. Lower division of labium.
F. Upper antenna.
G. Lower antenna.
H. First articulation of lower antenna.
P. Second articulation of lower antenna, represented by membrane with calcareous margin.
I. Mandible.
K. Inferior portion of the thin posterior segment of the cephalic region.
O. Internal portion of the last segment, (the homologue of the dorsal part): on this the stomach rests.
L. First maxilla.
M. Second maxilla.
N. Maxilliped.
Fig. 5. The part O seen from above.

PLATE XIII.

Fig. 1. Superior antenna of *Lysianassa*.
a, b, c. Varieties of auditory cilia.
Fig. 2. Inferior antenna of *Talitrus locusta*.
Fig. 3. Inferior antenna of *Chelura terebrans*.
Fig. 4. Inferior antenna of *Sulcator arenarius*.
Fig. 5. Inferior antenna of *Corophium longicorne*.
Fig. 6. Inferior antenna of *Podocerus*.
Fig. 6*a*. Inferior antenna, the point of *Podocerus*.
Fig. 7. Inferior antenna of *Hyperia Galba*.
Fig. 8. Eyes of *Tetromatus*.

PLATE XIV.

Fig. 1. Olfactory organs or base of inferior antenna in *Isæa Montagui*.
Fig. 2. Olfactory organs of *Gammarus gracilis*.
Fig. 3. Olfactory organs of *Gammarus pulex*.
Fig. 4. Olfactory organs of ditto, enlarged.
Fig. 5. Olfactory organs? of *Gammarus elegans*.
Fig. 5*a*. Two of the segments enlarged.
Fig. 6. Mandible of *Talitrus locusta*.
Fig. 7. Mandible of *Anonyx*.
Fig. 8. Mandible of *Gammarus gracilis*.
a. Molar tubercle.
b. Incisive edge.
c. Secondary edge with moveable joint.
d. Hairs or ciliated spines.
e. Muscles.
Fig. 9. *Dexamine spinosa*.

PLATE XV.

Fig. 1. Anterior labium of *Gammarus locusta.*
Fig. 2. Posterior labium of ditto.
Fig. 3. First maxilla of ditto.
Fig. 4. First maxilla of *Sulcator arenarius.*
Fig. 5. Second maxilla of *Gammarus locusta.*
Fig. 6. Maxilliped of ditto.
Fig. 7. Two segments from *Isæa Montagui,* showing their mode of attachment.
Fig. 8. Inside of the coxæ from *Gammarus,* showing the manner of their connexion with the legs and to the segments of the body.

PLATE XVI.

Diagrams showing the homologies of separate parts.

Fig. 1. Imaginary *Amphipoda.*
A. Cephalic ring or region.
a. Anterior portion, or infra antennal segment.
b. Posterior portion, or mandibular segment.
B. Pereion, or portion carrying the pereipoda or perambulatory legs. Thorax of authors.
B1. Anterior portion, bearing the two gnathopoda.
B2. Posterior portion, bearing the five pereipoda.
C. Pleon, or portion carrying the swimming feet (abdomen of authors).
C1. Anterior portion.
E2. Posterior portion.
1. Superior antenna.
c. Auditory cilia.
2. Inferior antenna,
a. Olfactory denticle.
3. Mandible.
b. Mandibular filament.
4. First maxilla.
5. Second maxilla.
6. Maxilliped.
7, 8. Two gnathopoda.
9, 10. Anterior pereipoda.
11, 12, 13. Posterior pereipoda.
14, 15, 16. Anterior pleopoda.
17, 18, 19. Posterior pleopoda.
20. Telson (extremity).
Fig. 2. Leg of *Macroura,* after Edwards.
Figs. 3, 4, 5. Legs of *Amphipoda.* The lines drawn through each joint demonstrate the homologies.

PLATE XVII.

Microscopic Sections of the Skin and Hairs.

Skin of
1. *Talitrus locusta.*
2. *Dexamine bispinosa.*
3. *Calliope Leachii.*
4. *Gammarus gracilis.*
5. *Gammarus locusta.*
6. *Gammarus Othonis?*
7. *Galanthis Lubbockiana* (leg).
8. *Tetromatus typicus.*
9. *Lembos Damnoniensis.*
10. *Chelura terebrans.*
11. *Amphitoë littorina.*
12. From thorax of 7.

Hairs of
A. *Sulcator arenarius.*
1. On legs, &c.
2. On maxilliped (3rd joint).
3. On maxilliped (5th joint).
4, 5. On carpus of gnathopoda.
6. On propodos of gnathopoda.
8. On propodos of gnathopoda.
7. On mandible.
9. On propodos, 1st gnathopoda.
10. On antennæ, &c.
11. On superior antenna.
12. On inferior antenna.
B. Hair from *Talitrus.*
C. Hairs from *Tetromatus.*
D. Teeth from maxilliped of species.
1. *Talitrus locusta.*
2. *Anonyx denticulatus.*
3. *Anonyx Holbolli.*
4. *Tetromatus typicus.*
5. *Tetromatus Bellianus.*

PLATE XVIII.

Organs of Respiration.

Fig. 1. *Sulcator arenarius.*
Fig. 2. *Gammarus locusta.*
Fig. 3. *Talitrus locusta.*
Fig. 4. Neck of 2, showing a tendency to a more leaf-like structure.
Fig. 5. *Caprella.*
a. Anterior.
b. Posterior.
Fig. 6. *Ægina longispinosa.*
Fig. 7. Internal structure of branchial sac, side near the middle.
Fig. 8. Ditto, from bottom of sac.
Fig. 9. Blood-corpuscles.
Fig. 10. Leg and branchia of young Decapod.
Fig. 11. Diagram showing the arrangement of the plates which form the incubatory pouch and the position of the branchial sacs.

PLATE XIX.

Alimentary Canal.

Fig. 1. Stomach of *Talitrus*, seen from above.
Fig. 1*a*. Œsophagus from *Tetromatus*.
Fig. 2. Stomach of *Sulcator*, lateral view.
Fig. 3. Stomach of *Gammarus* in situ, with the liver attached.
Fig. 4. Alimentary tube of *Sulcator arenarius* below the stomach, with the liver and urinary sacs attached.
Fig. 5. Appearance of the alimentary canal under two-thirds of inch power.
Fig. 6. Ditto, under one-fifth.

PLATE XX.

Fig. 1. Posterior portion of *Gammarus*, showing the urinary—
a. Organs in position.
b. Sphincter muscles at termination of urinary organ.
c. Sphincter muscles at termination of alimentary tube.
Fig. 2. Urinary organs from *Sulcator arenarius*.
Fig. 3. Urinary organs from *Gammarus grossimanus*.
Fig. 4. Urinary organs from larva of *Amphitoë rubricata*.
Figs. 5 & 6. Ultimate structure of the organ.

PLATE XXI.

Male.

Fig. 1. Testes from *Sulcator arenarius*, with their vas deferens and penis attached.
Fig. 2. Part of 7th segment, with coxa and penis attached.
Fig. 3. The under arch of 7th segment of pereion (thorax), with branchial vessels and penis attached, from *Gammarus*.
Fig. 3*a*. Extremity of penis.
Fig. 2*a*. Extremity of penis of *Sulcator*.
Fig. 4. Penis of *Caprella*.
Fig. 5. Spermatozoa of *Gammarus*.
Fig. 6. Spermatozoa of *Sulcator*.

Female.

Fig. 7. Ovaries of *Gammarus*.
Fig. 10. Ovaries of *Caprella* (after Goodsir).
Fig. 8. Vulvæ of *Caprella*.
Fig. 11. Plate from incubatory pouch of *Caprella*.

PLATE XXII.

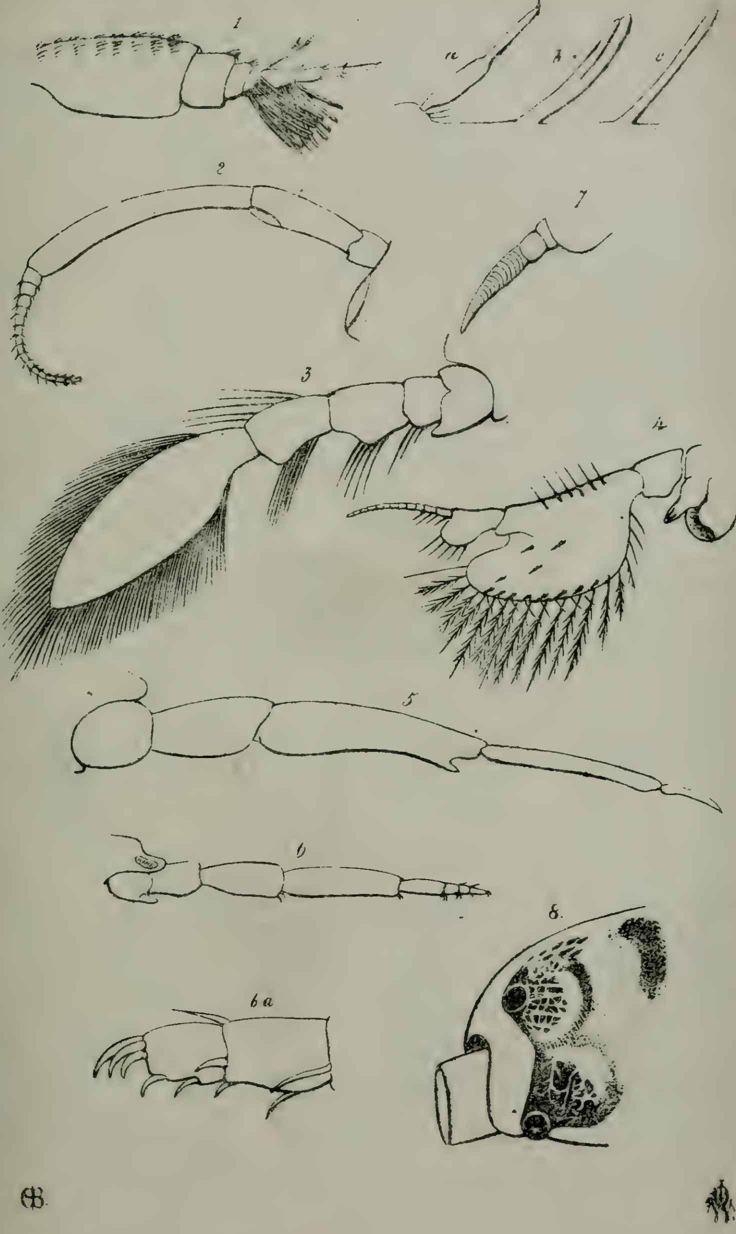
Fig. 1. Nervous cord of *Talitrus locusta*.
O. The calcareous arch under which it dips to the infra-œsophageal ganglion.
A. The cephalic or supra-œsophageal ganglion.
B. The infra-œsophageal ganglion hid by (O).
E. And following, one to each segment of the body.
Fig. 2. Lateral view of the internal arrangement of the head, showing the line which the nervous cord takes: letters the same.
Fig. 3. Diagram showing the circulation of the blood.

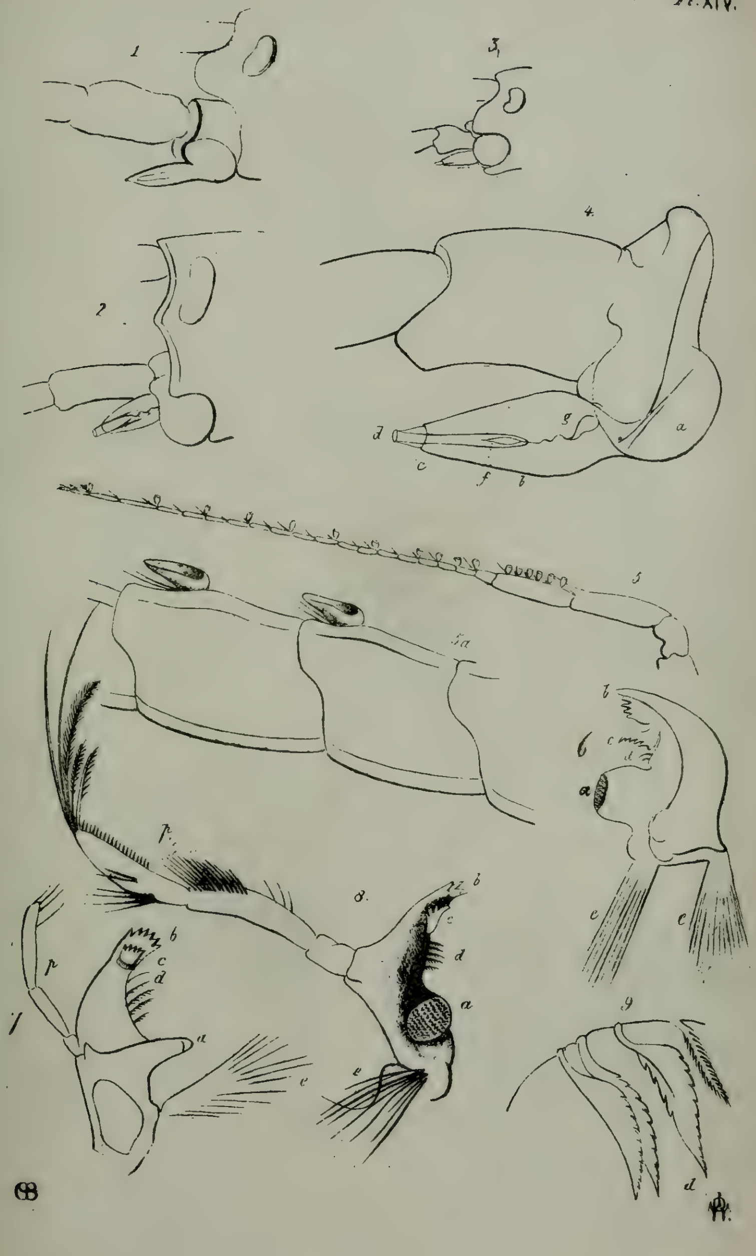
On the present state of our knowledge on the Supply of Water to Towns. *By* John Frederic Bateman, *C.E., F.G.S.*

Among the many interesting and important subjects to which the present desire for sanitary improvement has recently directed public attention, none have a higher claim upon that attention, nor are more intimately mixed up with the health, the comfort and the well-being of our town populations, than the questions of an abundant supply of good and wholesome water, the complete and proper drainage of our houses and our cities, and the purification of the streams and rivers into which the sewage of our towns is allowed to flow. Scientific research, and the experience of daily life, are constantly bringing to view the close connexion which these questions have with the mortality, the comfort and the moral habits of our rapidly-increasing population.

The tendency to herd together in large cities for purposes of convenience and employment, the rapidity with which many manufacturing towns have

Pl. XIII.

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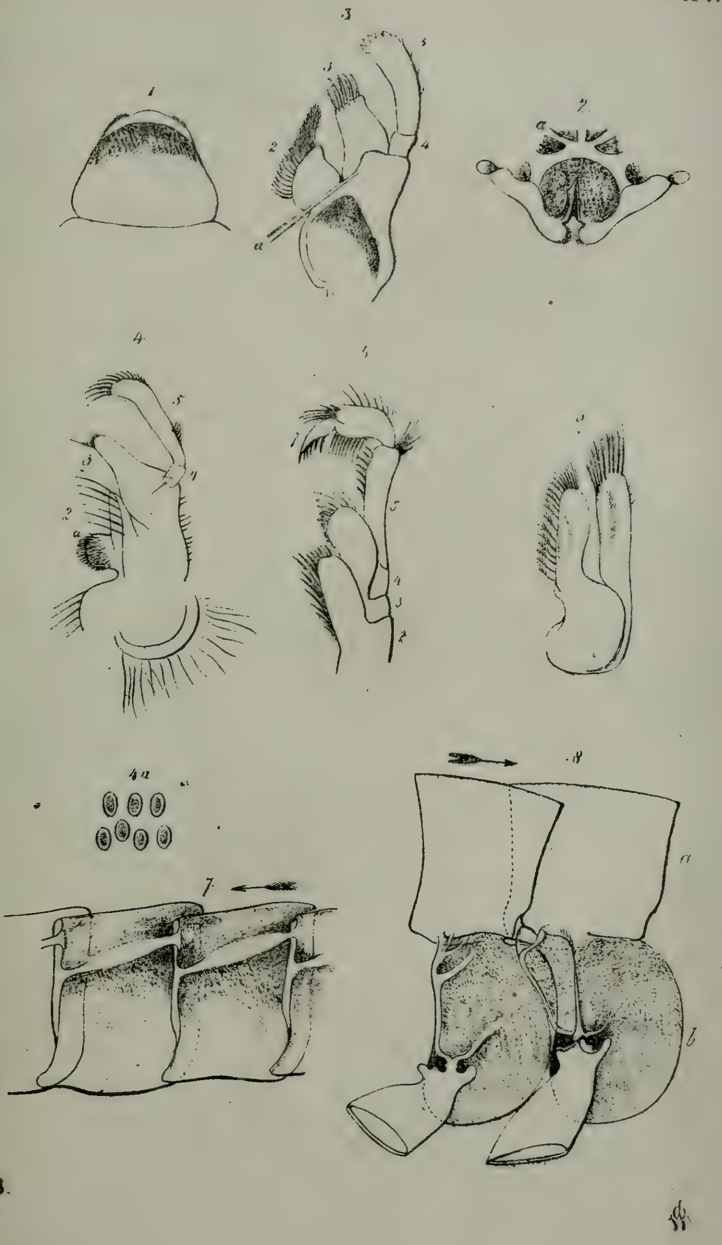

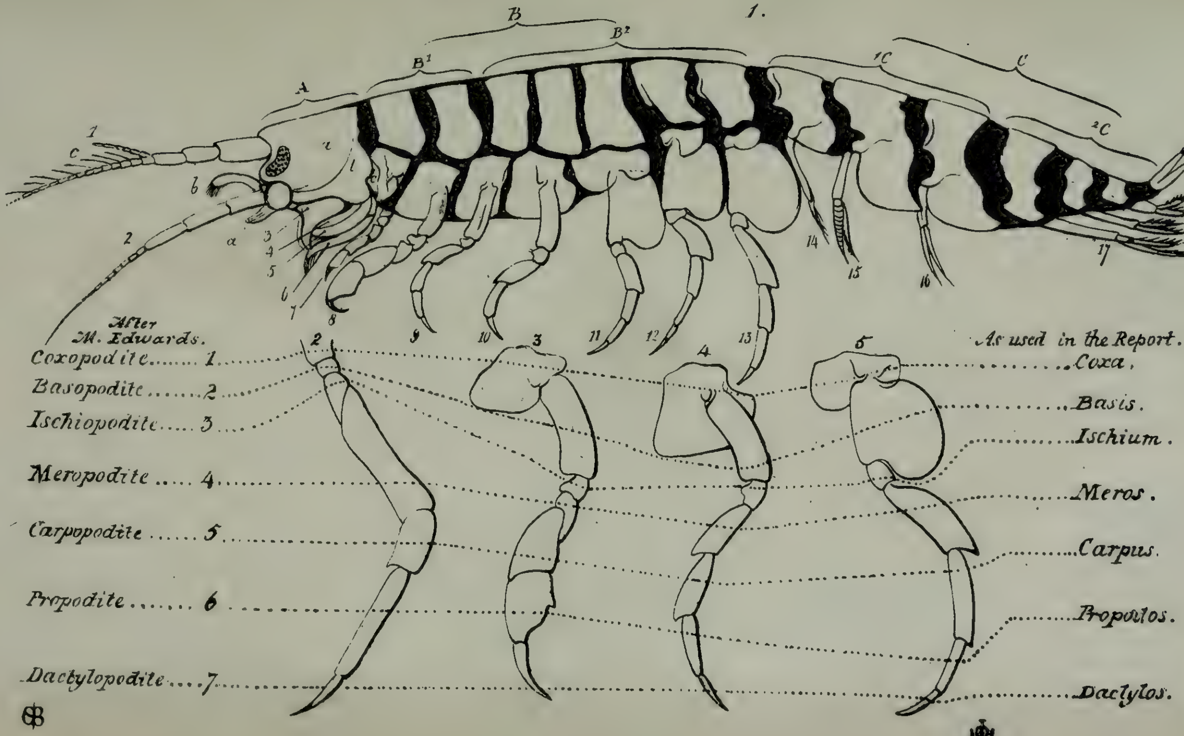
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M. Edwards.
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Ischiopodite..... 3
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Carpopodite 5
Propodite 6
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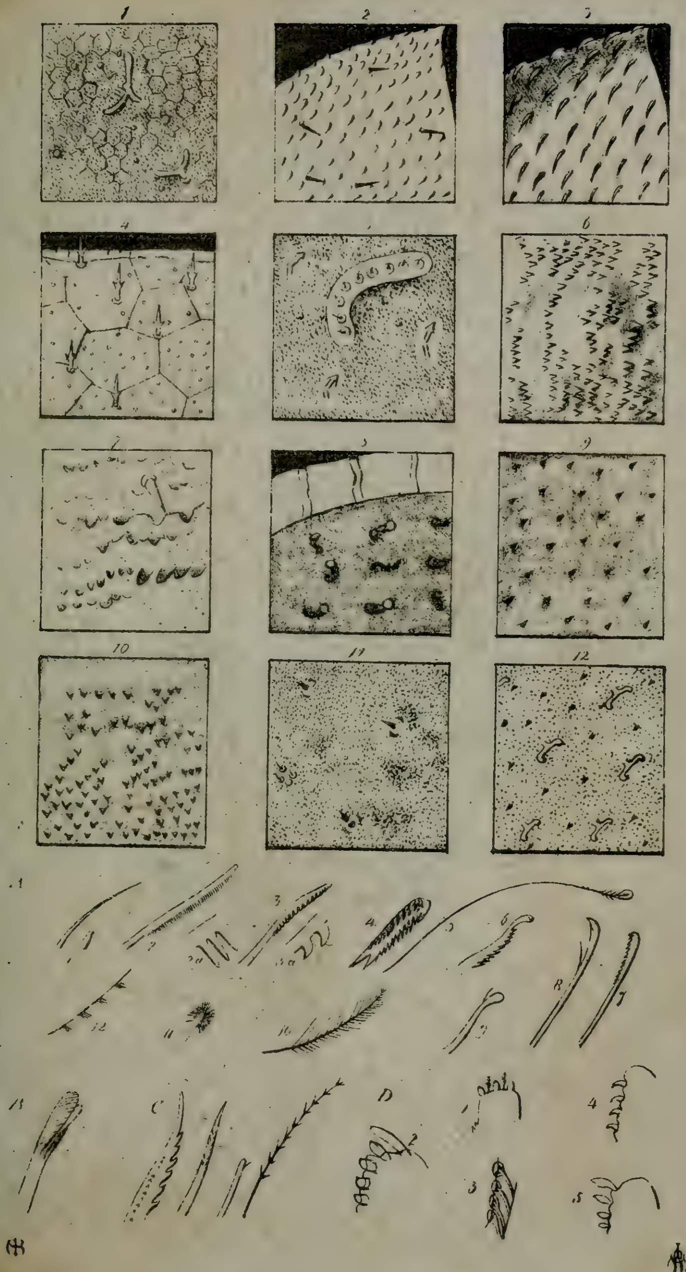
Pl. XVI.

Pl. XVII



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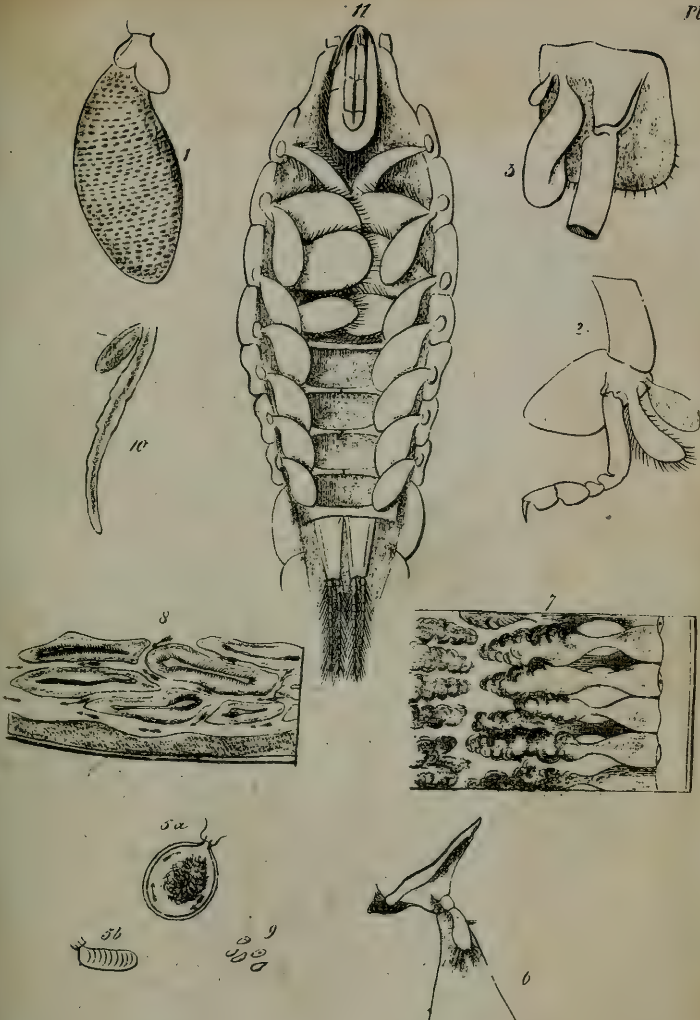

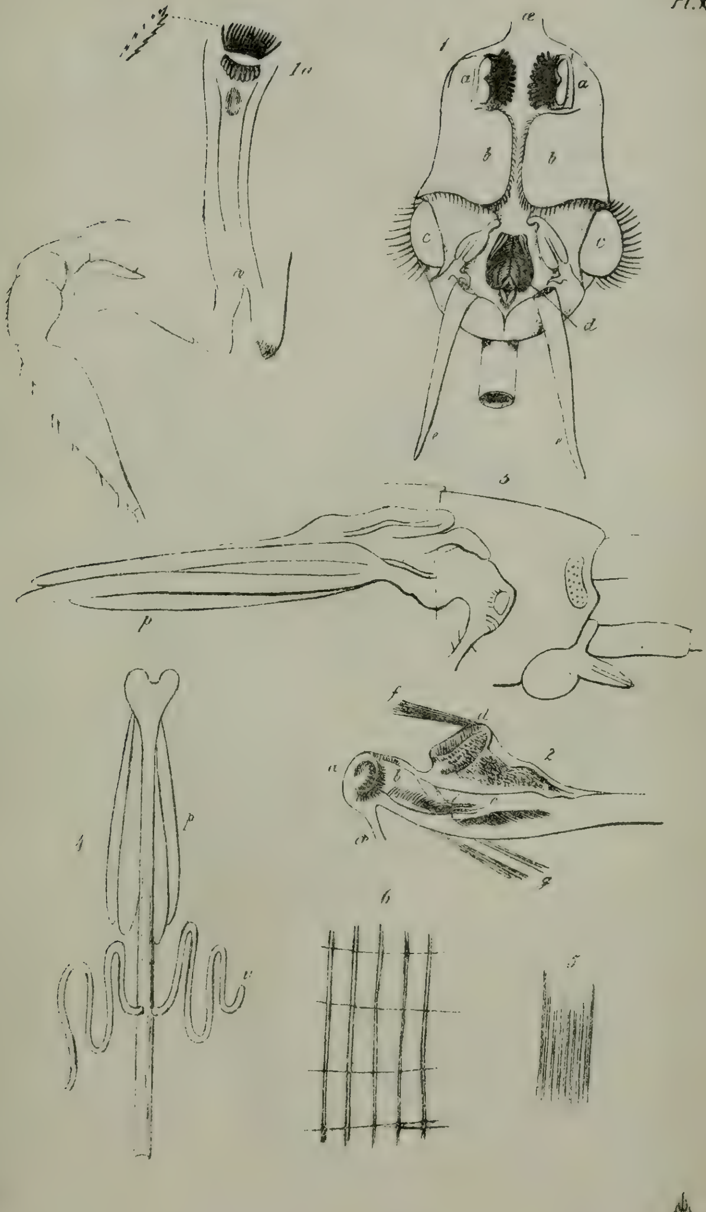
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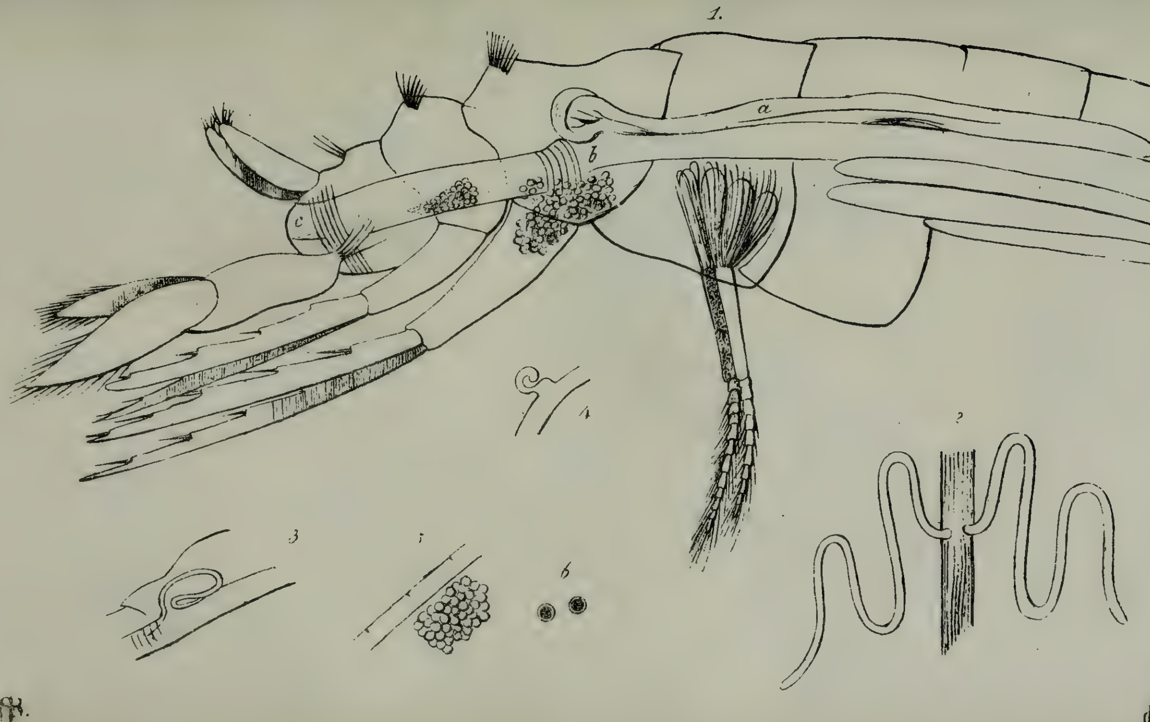
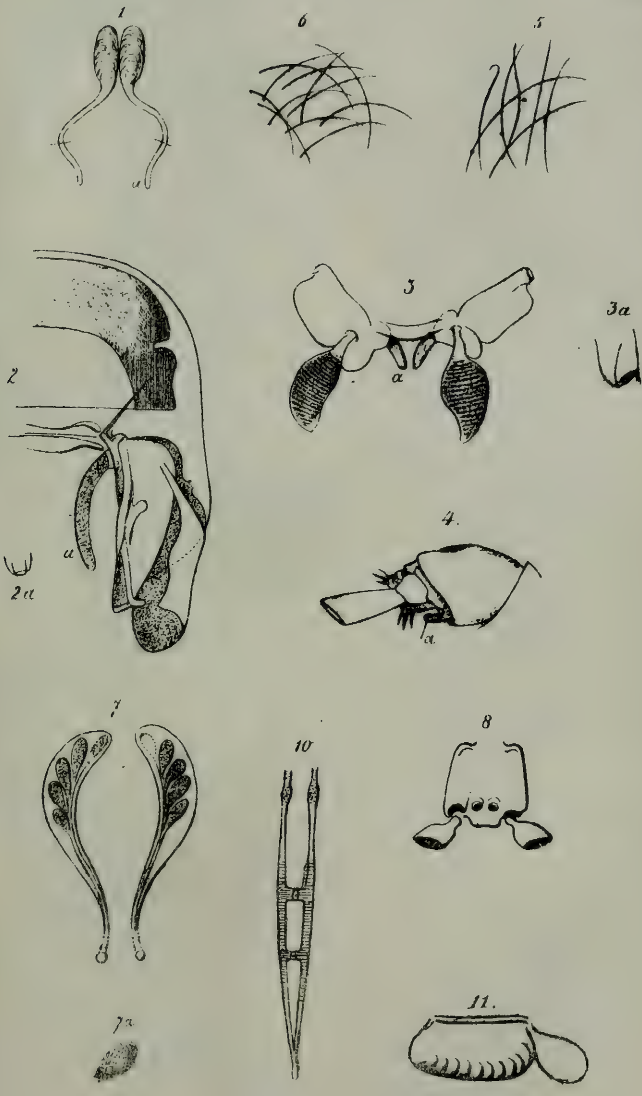


Pl. XX

Pl. XXI.



Pl. XXII.