perly for them, and should not be led to require as 'the thing' a lot of other information involving greater trouble and higher fees to the limitation of general reference to the chemist. The sooner the public learns that chemists do not want to take advantage of them, but only to do what is of use to them, and that fees are not to be regulated by the *number* of items given (any more than an amount of money by the number of coins of various values it may be paid in, but also by the intrinsic value of each), the better I think it will be."

In the foregoing Report the Committee has attempted to give an epitome of the very voluminous replies which have been received.

It will be perceived that there are many points on which the evidence is very conflicting; and the Committee feels it impossible to recommend with confidence any particular process or processes unless the special conditions of accuracy are very clearly defined.

The large amount of information amassed during the past year has indicated very distinctly the directions in which further research is desirable; and the Committee, if reappointed, will be able to complete the proposed experiments and inquiries before the next Meeting of the Association, and make a full report on the whole subject it was appointed to investigate.

Report on the Present State of our Knowledge of the Crustacea.—Part I. *On the Homologies of the Dermal Skeleton.* *By* C. Spence Bate, *F.R.S. &c.*

[Plates I. & II.]

In presenting a Report on the present state of our knowledge of the Crustacea, I do not think that I should fulfil the object in view without drawing attention to what must be one of the greatest hindrances to the progress of any study in an exact or scientific manner. I allude to the want of a uniformity in scientific nomenclature.

The names of the several groups and families, as well as those of the structure of the animals, given by the earliest carcinologists, having been based on a limited knowledge both of the forms and the variation to which this great subkingdom is liable, make them inapplicable to the knowledge of the period. Leach named one great group of Crustacea *Decapoda*, from the number of legs that it possesses; and Dana more recently named another group *Tetradecapoda*, from the fourteen legs that belongs to its most normal forms.

Observation has demonstrated that in this latter group some genera, as *Anceus*, have but eight legs; while in the Decapoda it is only a conventional rule that prevents the genus *Palæmon* and its allies from having the appendages of the pereion anterior to the last five pairs counted as legs.

But a greater difficulty still exists where the names given to any parts of the animal carry any significance with them that precludes their being accepted in their universally correct sense. Thus the third pair of maxillipedes in the Brachyurous Crustacea are identical with the first pair of walking-legs in the Stomapoda, Amphipoda, and most of the Isopoda.

It is now exactly twenty years (1855) since I presented to the Association a Report on the British Edriophthalmia, in which the same difficulty was pointed

out and a nomenclature suggested which, it was hoped, would to a large extent overcome the great difficulty in the study of this branch of natural history.

But although many of the terms there given have become very general in use, yet the custom of some writers of applying different ones at separate times for the same parts is significant of a confusion of ideas that precludes the student from a just appreciation of the labours of others.

I do not think that this difficulty will be overcome for some long period unless a committee is appointed by this Association, consisting of all the best known authors of carcinological works, who shall determine upon a systematic nomenclature for the structure and classification of the Crustacea to which all future writers shall conform.

In this Report I purpose provisionally, except when quoting from others, to make use of the same terminology as that adopted in the previous Report, and confine each term to that which has homologically the same signification.

In the classification of Crustacea in his great work*, Dana states that "in the crustacean type there are normally twenty-one segments, and correspondingly twenty-one pairs of members, as laid down by Milne-Edwards, the last seven of which pertain to the abdomen (pleon) and the first fourteen to the cephalothorax (cephalon and pereion). Now we may gather from an examination of the crab, or macrural decapod, acknowledged to be first in rank, what condition of the system is connected with the highest centralization in Crustacea.

"In these highest species, *nine* segments and nine pairs of appendages out of the fourteen *cephalothoracic* belong to the senses and mouth, and five pairs are for locomotion. Of these *nine*, three are organs of senses, six are mandibles and maxillæ."

M. Milne-Edwards, in his standard work 'Histoire Naturelle des Crustacés,' says, "We can generally distinguish among these animals a head, a thorax, and an abdomen; but the limit of these regions is not always naturally well defined; and it is not well to attach too much importance to these distinctions, for they do not correspond with the same parts among mammals, birds, &c. . . . ." And in a note to the above he says, "Guided by the principal viscera some authors have given the name of abdomen to the thorax, and that of postabdomen to that which we call abdomen; but after this principle we must consider the head to be a preabdomen, because it contains the same viscera as the thorax and abdomen."

The twenty-one somites of the typical Crustacea M. Milne-Edwards has thus divided—the anterior seven to the head, the next seven to the thorax, and the posterior seven to the abdomen. But in his nomenclature of the appendages the terms used are suggestive of the anterior two pairs of the thorax being attached to the head. In his "Observations sur le Squelette tégumentaire des Crustacés décapodes," Ann. des Sciences, 1854, the same author states that "he has often been convinced that in many branches of zoology the difficulties of the study are considerably augmented by the imperfection of the language by which we attempt to formulate the results of our observations. The employment of expressions that are vague in the determination of zoological characters and the description of the parts that constitute an organism convey naturally the superficial observation with which the observer was content, leaving in the mind of the reader an amount of doubt which retards his desire for distinct information . . . . . The terms," he continues, "of zoology are far, at present, from that degree of precision . . . . . These considerations have determined me to make a general revision of the

* United States' Exploring Expedition, p. 1397.

'carcinological terminology' before presenting to zoologists the work that has engaged me for some time on the natural distribution of Crustacea from the collection in the natural-history museum."

Even after this M. Milne-Edwards uses the terms head, thorax, and abdomen, which he had previously stated to be "regions not naturally defined," and gives the appellation of *pemptognathe* and *hectognathe* to the first and second pair of appendages attached to the thorax (or pereion). Dana made his researches on the highest form in crustacean life; so also has M. Milne-Edwards in his later observations. But the two appendages which this latter author determines as the seventh and eighth pairs of gnathes are invariably, according to his own showing, the anterior two pairs of the thorax. It is only in the highest and most consolidated form of crustacean life that we find them variated from their typical character so as to make them appear organs attached to the mouth; whereas in a very considerable proportion of the various forms of Crustacea they never act as attendants on the mouth, but are simply prehensile in their character or locomotive in their power: but almost universally throughout Crustacea they are connected with a pair of branchial appendages; and in this they fulfil most efficient work, so that in the highest types their connexion with the mouth is one of secondary importance only.

The first two pairs of appendages belonging to the pereion (or thorax), through nearly all the orders, of the typical crustacean exhibit a variation that distinguishes them from those posterior to them; and it may be convenient to define them, but certainly not by a term that confuses them with appendages that are only connected with secondary duties.

Taking into consideration the many and various forms of Crustacea, the great and numerous changes they undergo, it is desirable not only to be sure that the nomenclature shall be scientifically correct in its determination and homological signification, but that it is convenient and applicable to a very considerable proportion of the animals it has to define.

A typical crustacean in any of the well-defined orders can readily be divided into three parts, each part to consist of seven somites.

The *first division* we call the CEPHALON*. It consists of the anterior seven somites, and supports the organs of sense and appendages adapted to be attendants on the mouth.

The *second division* we call the PEREION. The seven somites that form this division support appendages that are more or less adapted for walking in their most normal condition.

The *third division* we name the PLEON. This consists of the posterior seven somites; these support the appendages which, when developed, are always more or less perfectly adapted for swimming.

The last somite of the pleon is almost universally variated from the others, and is developed much to resemble an appendage itself. It is, however, the posterior somite, and as such we designate it by the name of the *telson*.

The appendages that are attached to these several divisions are known by their relation to them. Those that are connected with the senses are determined by their character—such as the eyes, antennæ, and oral appendages.

The antennæ may be distinguished as the anterior and posterior pair, or as the auditory or olfactory respectively, in preference to that of the inner and outer or upper and lower, which is liable to vary. So the fourth pair of appendages, or the first belonging to the oral group, may be known (from their mandibular power) as the *mandibles*, while the three following may be deter-

* For the derivation of these terms see Report of the British Edriophthalmia, 1855.

mined by their relationship as the first, second, and third pair of *maxillæ*, or, as Professor Westwood has suggested, *siagnopoda*.

The appendages of the second division, or seven pairs of legs attached to the pereion, may be readily denominated the *pereiopoda*; but the anterior two pairs are commonly variated for different purposes. In Brachyura they fulfil the purposes of opercula to the mouth; in the Squillidæ and Edriophthalmic Crustacea they are adapted for prehensile and ambulatory purposes; so that it may be found convenient to recognize them by a distinctive name, as *gnathopoda*.

The appendages of the third division, or pleon, are never developed for walking or prehension, but almost universally are formed for swimming; and even in the Isopoda, where these are utilized as branchial organs, they occasionally fulfil the office of swimming-appendages. Not unfrequently the last two, as in the Macrura, and the last three, as in Amphipoda, are variated in form so as to enable the animal to spring when on land or dart a considerable distance in the water; and the term *uropoda* has been applied to them; but their variation is so inconstant that the advantage of defining them by any special name will be less than the convenience arising from the distinction.

The integumentary structure is one of the most important in the Crustacea, and a knowledge of the variations of its several parts is of much assistance, not only to the student of the history of these animals, but also for elucidating the knowledge of those forms that have passed away and can be studied only through the impressions left imbedded in the rocks.

The external skeleton of a crustaceous animal consists of series of rings, that appear to repeat each other, differing only in modification according to the necessity of the various portions of the animal. These rings represent and protect externally various segments of the body, each division supporting one pair of appendages only and the internal structure that relates to them. Each of these several divisions we call a "somite," a term suggested, I believe, by Professor Huxley in his lectures at the Royal College of Surgeons. Of these there are never more than twenty-one; and this may be considered as being the normal number in all Crustacea above those known as the Entomostraca, in some few of which, as in the genera *Apus* and *Stegocephalus*, the number of somites appear to be much more numerous; but there the somites appear to be repeated without having any function to fulfil or appendage to support—a numerical repetition only, the result of an enfeebled force.

The first somite supports and carries the organs of vision. In some of the most condensed forms the eyes are implanted on the outer side of the two pairs of antennæ; but the internal structure invariably shows that the most anterior pair of nerves are those that are connected with these organs. The progress of development which we purpose alluding to in its proper place clearly demonstrates the eyes to be the most anterior of all the organs.

The second somite bears the first pair of antennæ, which, from its position in the higher Crustacea, is generally called the inner pair, and from its position in the lower forms is called the upper pair of antennæ.

The third somite supports the second or posterior pair of antennæ; this, from its relative position to the other antennæ in the higher and lower forms of Crustacea, has been called respectively the outer and lower antennæ. This somite is so closely associated with the fourth that it is not certain that they exist distinct in any species of Crustacea.

The three anterior somites are generally closely blended together. In the earlier forms of development they are invariably so; but in *Squilla* and its

congeners the two anterior somites are distinctly separated from each other and the third. In *Palinurus* the first is distinct from the second; but in the greater portion of Brachyurous and Macrurous Crustacea the three first somites, and perhaps the fourth, are strongly soldered into one piece.

This piece in most Crustacea, but more conspicuously so in the more condensed forms, is developed to a greater or less extent, and is recognized under the name of the carapace or shield.

In the lower forms, such as the Amphipoda and Isopoda, it is developed sufficiently to cover only the four succeeding somites; while in the higher forms, such as the Brachyura, it is developed so as to protect the whole of the animal.

The carapace varies very much in shape, both in width and length, and generally covers the whole of the somites of the pereion; but not universally so. In the Anomura several genera have the posterior somite of the pereion exposed; in the Diastylidæ there are three or four somites not covered, and in the Edriophthalmic Crustacea all seven are unprotected and developed into perfect somites.

It is one of the earliest features present in the development of the embryo, and is distinctly defined in the *Nauplius* form. Even in this early stage of development, as in later existence, the form of the carapace varies considerably, and is an easy mark of distinction between genera. It is desirable as well as important, in an anatomical point of view, that a clear idea should be obtained of the homological relation of this large and conspicuous portion of the highly developed crustacean. This can be done only after an examination and comparison of a large number of various forms and types of animals, as well as a close investigation and study of the parts during their progressive development.

Milne-Edwards, as far back as 1834, arrived at the conclusion that the carapace in the higher types of Crustacea is "the result of an excessive development of the superior arch of the cephalic antenno-maxillary segment. . . . But (Hist. des Crust. vol. i. p. 26) among certain Stomapods, such as *Squilla*, the head is divided into many distinct segments; the first two, the ophthalmic and antennular rings, are movable and little developed. The third and fourth rings are, on the contrary, very large and compose between them a single segment that we call the antenno-maxillary. The carapace occupies the dorsal portion of the *tronçon* formed by this union, and is prolonged above the six following rings."

"In studying (*l. c.* p. 28) the carapace as a whole as well as in its parts, we must examine into the rules of the normal organization of Crustacea, not only in the later, more or less, remarkable modification, but also the very curious structure of certain Entomostraca, where all the animal is enclosed in a kind of bivalve shell."

These views receive general support from Mr. Dana, who, however, takes exception to the assertion that the ventral piece of the carapace is formed out of what M. Milne-Edwards calls the epimera (*l. c.* p. 32), but contends that they "are in fact the posterior extension of the mandibular segment;" and he continues, "excepting that we consider what is here called epimeral, the mandibular segment, we agree with Milne-Edwards, for the most part, in the above-mentioned deduction; so that while the mandibular segment is confined to the ventral pieces of the Brachyural carapax, it constitutes its posterior half in Macrura."

In 1855 the author of this Report communicated to the 'Annals of Natural History' a memoir on this subject, supporting the opinion of Milne-Edwards

as to the homology of the carapace, but denying the existence of epimera in the theory of the somite, and corroborating the assertion of Dana that the antennal segment constitutes the anterior and upper portion, and the mandibular segment the posterior and lower portion of the carapace in the Macrura and Brachyura; and affirmed that the suture which traverses the lower surface forms a line of demarcation between the third and fourth somites; it homologizes with the cervical suture in the Macrura, as also with that which traverses the dorsal surface of the cephalon in several genera of Trilobites (Pl. I. fig. 5).

If we wish to judge of the relation of these parts in the several forms of Crustacea, we must make a careful investigation during the immature stages of the animal.

In the *Megalopa* stage the inferior antennæ are attached to the anterior external horns of the carapace; these horns are folded beneath the animal, and it is this inflection that forms the orbit in which the eye is lodged. Through this inversion, consequent upon the monstrous development of the hepatic region, this suture lies upon the inferior surface of the carapace in Brachyurous Crustacea, extending posteriorly to the extreme limits of the carapace.

The author concluded his paper by saying, "But we have seen in the descending scale of nervous force the rings which carry the organs of consciousness degenerate in importance, and yield to a corresponding development of the mandibular ring: this law appears to be in force in the Amphipoda, the lowest type of the Macrura form, in which I am inclined to believe that the mandibular ring represents the whole of the upper portion of the cephalic articulation—the anterior three being so diminished in importance, that they are to be found only in the perpendicular wall of the head, or perhaps represented by their appendages only" (Ann. Nat. Hist., July 1855).

It would scarcely perhaps be necessary to enter further into the evidence that supports the homological relations of the carapace, had not Professor Huxley, in his Hunterian Lectures at the Royal College of Surgeons, expressed an opinion opposed to the above statements.

In his twelfth lecture Prof. Huxley says:—"In all the Brachyura and ordinary Macrura it appears to me to be obvious that the carapace is continuous with, and part of, all the somites of the cephalothorax—that it is composed, in fact, of their connate terga, the branchiostegite being nothing more than their connate and highly developed pleura; the cervical suture, placed immediately behind the attachment of the mandibular muscles and in front of the heart, corresponds in these respects precisely with the posterior boundary of the head of a *Squilla* and of a Branchiopod, or of an Edriophthalmian. The cephalic arc roofs over the stomach, as does the tergal region of the head in these last-named Crustacea. Anatomically, then, it seems to be demonstrable that the scapular arc of the carapace in the ordinary Podophthalmia is the equivalent of the terga of the thorax, that the cephalic arc is the homologue of the terga of the head, and that the carapace is formed by all the cephalothoracic somites."

Before the Reporter can proceed with any fresh evidence to support the argument demonstrative of the homological character of the carapace, it is desirable that a clear idea should be given of the theory of a somite or segment as it exists in Crustacea.

Prof. Milne-Edwards, in his 'Histoire des Crustacés,' vol. i. p. 16, says:—"Each of the rings of the skeleton appears to be composed of two lateral moieties, resembling each other. We can distinguish moreover two arcs, the one superior, the other inferior, as shown in the accompanying diagram

[pl. 1. fig. 3 of his work]. The former results from the assemblage of four pieces more or less intimately connected together, and arranged in pairs on each side of the median line. The central pieces are called by the name of the *tergum*, and the lateral are called the *flancs* or epimeral pieces. The inferior arc is composed of the same number of pieces. The two median pieces unite to form the *sternum*; and the latter are known by the name of the *episternum*, by reason of their analogy with those that M. Audouin has designated by the same name among insects. They are united always at the sternum; but there generally exists, between the inferior arc and the epimera situated above, a wide space destined for the articulation of the corresponding member."

"We know of no example," he continues, "of a ring where we are able to distinguish at the same time all the pieces that we desire to enumerate. Sometimes there is an absence of some of the pieces from the place they should occupy, and sometimes they are very intimately soldered together, so that we cannot see even a trace of separation; but in studying each of them separately, where it is most distinct, we shall be able to form a clear idea, and recognize its character in spite of its union with its neighbouring pieces. Moreover, although this analysis of the ring may not be always practicable, it is not the least true that it facilitates much the study of the exterior skeleton of articulated animals, and that it will permit us often to establish analogies where there would first appear to exist the greatest difference."

"To terminate the enumeration of the constituent parts of the tegumentary rings of the Crustacea, there only remains for us to speak of the plates that we often see elevated from the internal surface and arrange themselves into cells and canals. These processes are always developed at the points of union of two rings or of two neighbouring pieces of the same segment; and this disposition has obtained for them the name of apodemes (from M. Audouin). They are the result of a fold of the integumentary membrane which penetrates more or less deeply between the organs, and which is strengthened with calcareous matter like the rest of the structure, and are always formed of two thin plates soldered together."

These views have long been accepted as the acknowledged theory. Nor am I aware that any one (except the authors above quoted) has attempted upon original investigation to analyze the evidence upon which M. Milne-Edwards has formed his theory.

That the author of this Report has long held views not consistent with M. Milne-Edwards's theory, is known to those carcinologists who have read his Report on the British Edriophthalmia, which was communicated to this Association and published in its Transactions for 1855, wherein he trusts that he clearly demonstrated that the pieces to which M. Milne-Edwards gave the name of *epimera*, and selected by him as typical of his theory, were parts attached to the legs, and not pieces of the dorsal arc of the crustacean somite.

He is moreover desirous in this Report to show:—that the epimera, as sectional pieces in a theoretical construction of a somite, cannot exist; that the so-called epimera are portions only of the integumentary structure of the appendages of the animal, and that the apodema are formed out of this structure, more or less thinned out by lateral pressure and internal arrangement; and that the head of the lower types and carapace of the higher are homologically the same, the carapace being a monstrous development intended for the covering and protection of the more complicated branchial appendages of the higher types.

But this portion will be discussed more fully when the structure of the appendages is treated of.

The earliest stage in the life of a crustaceous animal, in which the dorsal shield known as the carapace is observable, is that of the young as it exists fresh from the ovum of a cirriped (Pl. I. fig. 1). This, which has been named the *Nauplius* form of the Crustacea by Fritz Müller, exists as a small animal with three pairs of appendages only. The eyes are not developed, the ocular spot not being homologous with the permanent organs; but since we see that material does enter into the stomach, we can have no great effort in accepting the proposition that this incipient animal has a mouth; and such being the case, we must assume that the anterior four somites are present in the construction of the head of the *Nauplius* stage of Crustacea. The oral apparatus is still in an embryonic condition.

The next stage of living types in which we can observe the carapace to exist in the progressive condition is in that known as the *Zoëa* form of Crustacea (Pl. I. fig. 2). This is the early life of the young of the higher Podophthalmous Crustacea. That of the Brachyura is most known and most instructive. Some of the appendages are beginning to assume a permanent form. The eyes are developed, the antennæ (though in an immature condition) are in existence, and so are all the appendages of the head except the last. The first two pairs of appendages connected with the pereion are present in an immature condition, and the posterior pairs are represented by small bud-like appendages. Dissection readily demonstrates that the carapace in this stage only covers, but has no associated connexion with, the appendages of the pereion; and a closer study shows that the heart is connected with and partly exists in the great dorsal spine. The relative position of this process, therefore, enables us to determine that the future growth of the carapace takes place and is connected with the anterior portion of this structure, and not with the posterior. In the young of *Palinurus*, as well as in the larger forms known as *Phyllosoma*, which appears to be the young of *Palinurus* older in age and larger in size, the carapace is developed largely in advance of the oral apparatus; it is produced posteriorly so far as to project over the anterior two somites of the pereion, but is not attached to any portion beyond the posterior oral appendages. An examination of the *Zoëa* of the various types of Podophthalmous Crustacea supports this observation; and we can trace the same facts from the *Zoëa*, through the *Megalopa*, to the adult Brachyurous Crustacea (Pl. I. fig. 3). It is therefore desirable that we should see how far the study of an adult crustacean will assist us in demonstrating the true relation of the carapace to the general structure of the animal.

In *Squilla* and allied forms of the same type the two anterior somites (the first of which supports the eyes, the second the anterior pair of antennæ) exist as distinct and perfect, though small somites; whereas the two succeeding are closely associated together, and appear as a large dorsal plate supporting the posterior pair of antennæ and mandibles. The posterior three somites belonging to the cephalon and the first two belonging to the pereion are represented by the sternal plates only. In the young forms the anterior two somites belonging to the pereion are in a membranous condition dorsally complete.

According to the theory of Professor Huxley, the carapace represents the dorsal arc of all the somites that it protects and have not a distinct roof of their own.

It is therefore desirable that we should learn what may be the distinct useful value of the carapace, and why each somite would not serve the same purpose by being perfect in its own arc.

The branchial organs, that are so essential to the aeration of the blood in all aquatic animals, are in the Crustacea appendages attached to the members belonging either to the pereion or pleon or both. In the lower and terrestrial types, such as the Isopoda, they are connected with the pleon only. In some Stomapods, as *Squilla* and its allies, we find them attached to the pleopoda as well as the pereiopoda; but in the higher groups they are invariably attached to the pereiopoda only. In the most simple form the branchiæ exist as mere saccular attachments, whereas in the higher types they become more complicated and voluminous. In the saccular condition they are held by a small neck pendent from the joint, and are exposed in the water without protection; but in the higher Podophthalmous types they are formed of very numerous plates folded close together upon a central stalk, and would be very liable to injury if not protected by some means.

The branchiæ, therefore, being in their very nature external organs, and attached to the first joints of the several appendages of the pereion, it is self-evident that they could not be covered or protected by their own somite, inasmuch as if it had passed over them the branchial appendages would become internal. Their character and constitution would therefore be changed; they would cease to be external; in fact they would cease to be branchiæ.

But since the appendages exist as branchiæ and are covered and protected, it must follow that if the protection cannot be evolved from the somites to which they are secondarily attached, the covering must be the result of the development of some other somite.

The somites in their simple conditions have a tendency to overlap one another to an extent that precludes them from permitting any portion of the intermediate structure being exposed.

That the somites have a tendency to extend in every direction, is very evident from the different proportions and forms they severally undergo in various genera, and those which compose the carapace exist in all proportions.

In the Isopoda the cephalon is reduced to the smallest extent in a typical form of Crustacea. In the Amphipoda the cephalon is much larger than in the Isopoda; but in neither of these is the integumentary covering produced to cover or protect any somite that is not included within its anatomical bounds. In the Diastylidæ, one of the lowest forms of the Schizopod type (where the branchiæ consist of but one or two pairs of a multicellular form), the tergal projection of the cephalon extends posteriorly over half the pereion; whereas the lateral walls are anteriorly produced, so as to protect and cover the anterior cephalic appendages. These animals burrow and live in the mud and sand; and no doubt this development of the carapace forms a good protection to the eyes and antennal organs. Thus we can readily interpret the origin and homologue of the shell-covering in *Limnadia*, *Cypris*, &c., by supposing a monstrous development of the carapace in every direction, induced as a protection to a feeble animal that but for this protection must perish in its destructive habitat.

In *Squilla* and its allies (the typical form on which Milne-Edwards has based his researches) the carapace does not extend posteriorly beyond its anatomical bounds; laterally it projects interiorly more so; but the great size of this plate arises from the large amount of space that exists between the mandibles and the antennæ; and as a carapace it is scarcely more important than the tergal surface of the cephalon in the Amphipoda. The branchial organs in this type of animals are saccular, or more rudimentary in their condition than the same organs attached to the pleon. The carapace as a covering is not required to protect these branchial organs, which are

not more important than the same in the Amphipoda. Gradually, as the branchiæ assume a more complicated or multicellular condition, the carapace increases in dimensions both laterally and dorsally, until we perceive it reaches the important feature we find in the Brachyurous Crustacea.

In *Squilla* the eyes are borne on a distinct somite; in *Palinurus* the same is distinctly visible; in *Cancer* the ophthalmic somite is likewise distinct and separated from the next succeeding, but it is wrapt over and enclosed by the next or anterior antennal somite. In *Squilla* also the first pair of antennæ are borne on a somite distinct from the succeeding. In the Macrura and Brachyura this and the succeeding somites are closely blended together; but in *Squilla* the fifth, sixth, and seventh somites are capable of being determined by their sternal pieces only. As we perceive the tergal pieces of the somites of the pereion are wanting in the Brachyura, so we may assume that they are not developed in the posterior somites of the head in *Squilla* under similar conditions. There therefore is every reason to believe in the theory, that the monstrous development of the mandibular and posterior antennal somites, incorporated together, unite to form the perfect carapace that is so characteristic of the typical Crustacea.

But whatever may be correct in a theoretical or transcendental point of view, for all anatomical and practical requirements the carapace represents the tergal surface of the cephalon, so largely developed as to cover and protect not only the pereion, but, as in *Cryptolithodes*, the entire animal.

In the development of the Crustacea the gradual progress of the carapace may be traced through all its stages.

In the ovum the members are first represented by small gemmiparous sacs, and precede the formation of the dorsal or ventral arcs in the small *Nauplius*. The carapace covers and protects all the animal except the pleon; but this represents only the four anterior somites and their appendages. In the *Zoëa* stage the carapace is perfect and folded downwards laterally, and is capable of covering and protecting all the appendages of the cephalon and the anterior two of the pereion. At this period no branchial organs exist, but saccular appendages in an embryonic condition are budding in their places: in a short time the pereiopoda are seen to form, and the branchial organs assume a definite character; and with their appearance a change takes place in the form of the carapace.

In a large number of Brachyural *Zoëæ* a more or less conspicuous spine or tooth-like process may be seen to occupy a position on the lateral walls. This spine, from observation during the progressive growth of the animal, is seen to correspond with the angle in the adult that defines the demarcation between the branchial and hepatic regions. The deflection of the carapace anteriorly bends over the hepatic lobes, the line of the greatest curvature being frequently surmounted by a series of well-defined tooth-like cusps; and posteriorly bends over the branchial organs, the curvature here being less abrupt and seldom surmounted by any cusp or process.

Externally the carapace covers and protects both the hepatic and branchial organs; but internally a calcareous wall of demarcation exists.

This wall, which Milne-Edwards terms the apodema, is continued into a thin membranous tissue that makes a distinct and well-defined separation between the branchial appendages and the internal system; so that the aqueous element, so necessary for the aeration of the blood as it passes through the branchiæ, may have full power to play upon the gills without having any passage that would admit it to the internal viscera and derange the general economy of the animal.

Not only does the carapace vary in external form, but also in the configu-

ration of its surface. The relation that it holds to the internal viscera is to afford protection and means of support.

When the former only is required, the structure is generally smooth and even; where the tissues are internally thicker and irregular, it gives to the external surface an indented and irregular aspect, which is common, particularly in the flat and short-tailed Crustacea, where the markings are so persistent as to afford a very valuable assistance for the determination of species.

These markings are generally induced by the attachments of the tissues that secure certain viscera in their positions; these form generally points of depression; but where any organ (such as the liver, stomach, or branchial appendages) is protected, the corresponding points in the carapace are elevations, sometimes crowned with a pointed spine or process. The branchial appendages are external in relation to the body of the animal, but covered over and protected by the lateral walls of the carapace. To complete this so as effectually to protect those organs without pressing on or interfering with their functions, a very considerable amount of lateral development has taken place, and a peculiar reflection so as to bring the margin of the carapace below the branchial appendages and to protect them from rude contact with the limbs. The angle which is induced by this inflection of the carapace over the hepatic lobes and enclosing the branchiæ is generally well defined and ornamented with points or processes more or less numerous. These processes define the dorsal limits of the carapace.

Desmarest, half a century since, mapped out the dorsal surface of the carapace into regions coinciding with the limits of the internal viscera.

Milne-Edwards, in his 'Histoire des Crustacés,' published in 1839, adopted the same views, supporting it by illustrations from several genera.

Professor Dana more recently, in his great work on Crustacea, has divided the dorsal surface into many more regions, taking the numerous areolites that are present in some genera (as *Zozymus*).

He divides the carapace by a transverse line that extends from just anterior to the last of the normal lateral teeth to the same on the opposite side, and separates it into anterior and posterior portions.

The anterior he again divides into three parts, defined by lines of depression, and names them the median region and two antero-lateral regions.

The median region covers the stomach, and includes the gastric and genital regions of Desmarest.

The space anterior to the median region he calls the frontal, and on either side the orbits form another, which may be called the orbital region.

The posterior portion of the carapace he likewise divides into a posterior and two postero-lateral regions.

Professor Milne-Edwards in 1854 readdressed himself to this subject and further elaborated it. In the 'Annales des Sciences Naturelles' he communicated his researches with illustrations from several genera, and divided the dorsal surface of the carapace into regions corresponding with the names of the internal viscera. But it appears to me that the correspondence in many parts exists in the name only; as, for instance, in the gastric region, which he subdivides into epigastric or anterior lobes of the gastric region, protogastric or latero-anterior lobes, mesogastric or median lobe, metagastric or latero-posterior lobes, and urogastric or medio-posterior lobe of the gastric region.

It is quite within the power of demonstration to prove that it is more in accordance with the correct anatomical details of the animal's structure if the lobes that he named metagastric, or latero-posterior lobes, were called, according to Desmarest, the genital regions after the viscera they protect. And no advantage appears to me to be derived from dividing a region

into parts that are not constant, and when present do not represent any internal organization, as he has done in dividing the branchial region into :— epibranchial, or anterior division of the branchial region; the mesobranchial and metabranchial divisions, which consist of lobes variable in form, but represented in most genera by a smooth surface.

The cardiac region he divides into an anterior and posterior portion. The anterior alone represents the position of the heart; the posterior represents the part that lies between the heart and the posterior margin of the carapace.

The hepatic regions he does not subdivide, but circumscribes their limits within the extent of the internal organ—an object of consideration, as it appears that the extent of this organ is one of the most important features in the moulding of generic forms. The other regions are those situated on the ventral surface, and which will be considered in a future Report.

The value of a clearly defined knowledge of the various markings that are represented on the dorsal surface of the carapace of Crustacea is best appreciated in the study of fossil specimens, where the remains of animals, however well preserved, can be read by their external features only.

It is therefore with a view to accelerate this that I have in this Report endeavoured to lay down the several regions that are represented by the markings exhibited on the surface of the carapace.

Taking advantage of the information conveyed by studying the labours of the previously mentioned eminent carcinologists, I have laid it down as a rule for guidance, that the external markings must define the internal structure; and where this is not the case the lobe or projection exists as an excrescence.

The most important and constant divisions are :—

The anterior, which lies immediately above the antero-œsophageal ganglion. This may readily be subdivided into the orbital and antennal portions. The entire region, from its relation to those organs from which alone intelligence is derived, may be termed the cephalic region.

Directly posterior to the cephalic region is the gastric; this is generally very conspicuous, the intensity of the postero-lateral markings being rendered more distinguishable by the inner surface of the carapace being adapted for the attachment of the anterior tendon of the mandibles.

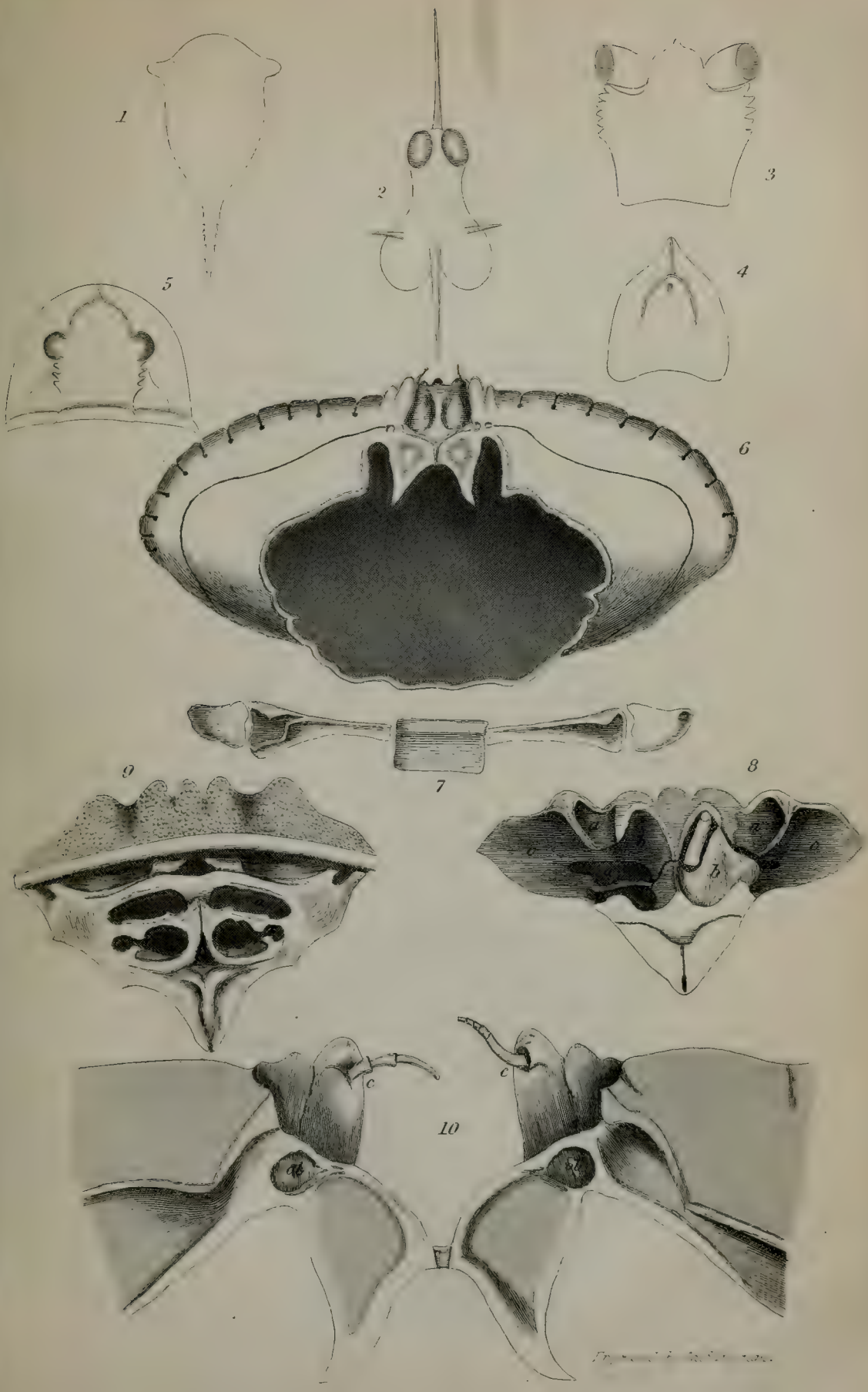
The stomach consists, in the more perfectly developed types, of a large central chamber, the form of which not only varies in genera, but is capable of extension and of being collapsed in the same individual. It has also antero-lateral cavities and a posterior or pyloric extension; but these are produced at a lower line, and therefore liable to be less conspicuously represented on the dorsal surface.

The lobe which M. Milne-Edwards has termed the mesogastric, corresponds with that portion of the stomach that is projected above the gizzard-like plates that stand at the entrance of the pyloric chamber.

On each side of the pyloric or mesogastric lobe are two generally well-defined lobes that correspond, and are probably induced by the presence beneath of the genital apparatus in the male and the commencement of the ovaries in the female. I think, therefore, that it is desirable to retain for these lobes the name that was first bestowed upon them by Desmarest, and call them the genital regions.

Posterior to these comes the cardiac region, which corresponds very closely with that of the heart, which lies immediately beneath it.

Posterior to the heart the carapace protects no distinct viscera; but the posterior margin covers the anterior half of the first somite of the pleon. The muscular system which moves the pleon is attached to the apodema that divides the cardiac from the branchial cavities, which also affords attachment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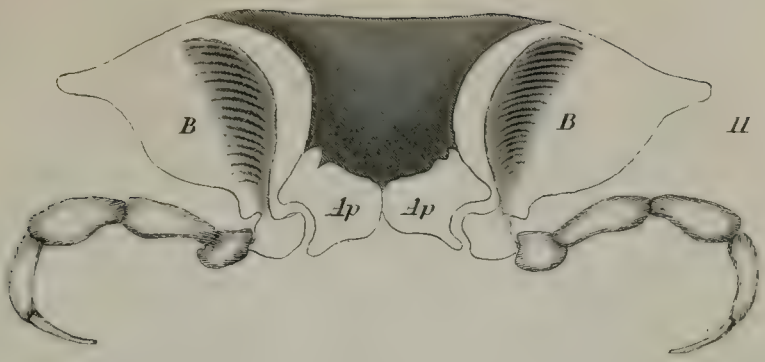
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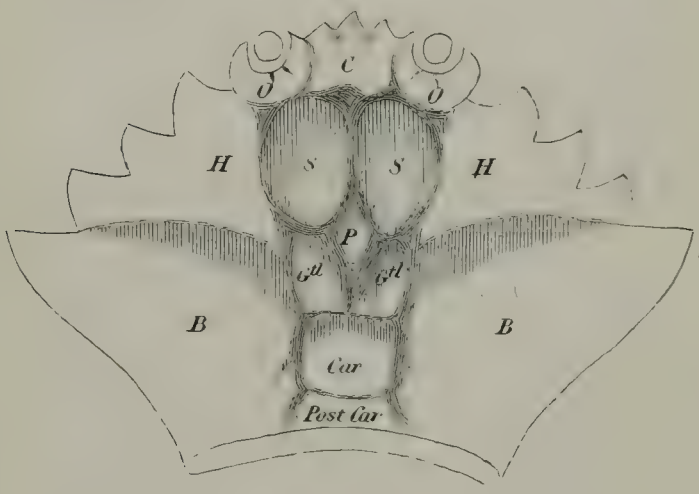
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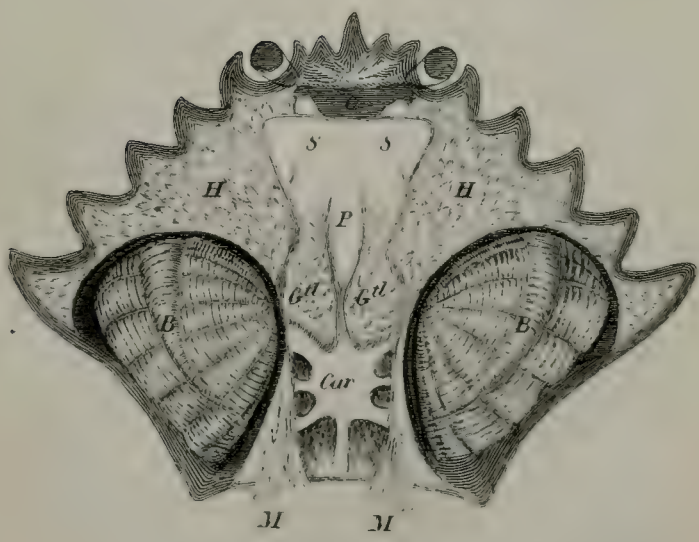
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