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A

MONOGRAPH

ON THE

STRUCTURE AND DEVELOPMENT

OF THE

SHOULDER-GIRDLE AND STERNUM

IN THE

VERTEBRATA.

BY

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PREFACE.

In the present Memoir there are embodied certain of the late Professor Rathke's invaluable researches with my own, so that some of the fruits of his labours now appear in an English form for the first time. Whatever value may be put upon my work, of this I am confident, that we have done good service to anatomy in this country by giving readers who, like myself, know only their mother tongue, the advantage of some of Rathke's labours.

Other parts of this great embryologist's works have been translated for us already by Professor Huxley, and I now offer to the anatomical student more treasures from the same source, which have been kindly translated for me by Mr. Power.

With very few peers, and no superior, as an observer of facts, Professor Rathke modestly limited himself in the naming of new elements; and he really needs a continuator, who will fully verify and extend his researches, without being reticent as to general and special homological relations.

Some of my own observations are accidentally mere repetitions of what that eminent anatomist had noted some twenty years before, but unfamiliarity with books made them appear to me to be real discoveries.

As for myself, I have never been able to work in the same patient and uninterpreting manner as Rathke was wont, for during an early period of my work I was allured out of the "old paths" by Transcendentalism; and often again since then I have found myself astray on the "high priori road."

Nevertheless, I have learned at last that if "a man will begin with certainties he shall end with doubts;" and to my help I have had the frequent and friendly aid of Professor Huxley, who, in this country, is most worthy to represent the great German embryologists.

Whilst this Monograph has been passing through the press, it has undergone careful revision by my talented friend Professor T. Rupert Jones. To him, to Professor Huxley, to

Mr. Power, and to all who have with friendly mind and ready hand helped me, I now return my hearty thanks.

It ought to be mentioned that the Royal Society has granted a Hundred Pounds towards the expenses of the Plates for this Memoir; and also that, in putting my drawings on stone, in drawing some of the objects from nature, and in colouring the figures, Mr. George West has shown his usual facility and conscientious care.

LIST OF WOOD-ENGRAVINGS.

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CORRIGENDA.

Page 9, line 2 from top, *for* Dumeril *read* Duméril.

„ 59, line 3 from bottom, *for* South American *read* North American.

„ 86, line 11 from top, for *Kabasson* read *Kabassou.*

„ 90, foot-note, line 5 from bottom, *for* Gegenbaur's *read* Gegenbauer's.

„ 101, line 3 from top, for *Brustbeius* read *Brustbeins.*

„ 169, line 8 from bottom, for *Caprimuglus* read *Caprimulgus.*

„ 178, foot-note, line 2 from bottom, for *Œgithognathæ* read *Ægithognathæ.*

In Plate XXII, at fig. 5, for *s. r.* 5 read *s. r.* 4.

THE

SHOULDER-GIRDLE AND BREAST-BONE.

INTRODUCTORY REMARKS.

The germ of the present Memoir will be found in the 'Proceedings of the Zoological Society,' June 28th, 1864 (Part 3, pp. 339—341), and, for the most part, the observations recorded here are merely a development of those to be found in that brief report.

I was not aware, at the time when I read that paper, that the real nature of the Tortoise's "plastron" had been discovered by the late Professor Rathke many years before; but as early as 1848 he had given a true account of its structure (see his Memoir 'Ueber die Entwickelung der Schildkröten,' pp. 122—131); when I come to the Chelonia I shall insert a translation of his remarks on that subject.

In my small paper there is a very grave error, which I discovered too late to correct. I supposed that the "furcula" of the Bird answered to the azygous "episternum" (so-called) of the Lizard,[1] whereas that bone includes both the "episternum" and the clavicles.

This error led to another. I supposed the clavicles of the Lizard to answer to the antero-inferior shoulder-bars of the Frog, which belong to the "coracoid" category, although they have often been confounded with the clavicles.

Nor had I discovered, when my abstract was printed, that the foremost bones of the Tortoise's "plastron" are the true homologues of the three shoulder-splints of the Lizard, the Bird, and the Monotreme; nor that the two outer ones—the so-called "episternal" pieces—are

[1] Dr. Gray makes a similar mistake with regard to the "episternum" of the Monotremes (see 'Zool. Proc.,' part ii, 1865, p. 385); he calls it the "furcula."

the counterparts of those great outer shoulder-bones of the Osseous Fishes, which Professor Owen has called "coracoids." It will be seen, however, that I still wholly reject the nomenclature which the same eminent anatomist has given to these and to the rest of the shoulder and fore-fin bones of Fishes.

These subjects will be treated of in due time; and although I wish to work peacefully, yet it will be seen from the Abstract of my Paper that *controversy* was one of the exciting causes of this particular line of research.

If any apology be needed for writing so large a book upon so restricted a subject, I would say that it is a narrow *balk* running through a very wide field, and that its cultivation will remove many an unsightly error and reveal a number of beautiful and valuable truths.

Moreover, I do not believe that the anatomist exists who is strong enough to master the facts of anatomy whilst they are bound up in one faggot or "system;" but, taken part by part, they may be mastered by the most unpretending worker.

Then, in the times to come, when we have "prepared our work without and made it fit for ourselves in the field," we shall be able to build a "system of anatomy" which shall truly represent Nature, and not be a mere reflexion of the mind of some one of her talented observers.

The plan of the present paper is to begin the study of the Shoulder-girdle in the Rays, where it is most largely developed and most generalised; and then, tracing its growth in some of the chief Ichthyic types, to follow up its development until we come to Man, at the head of the Vertebrate series.

As the lowest or Suctorial Fishes have no limb-girdles, I am obliged to begin some little way up in the Class: it is the same with regard to the sternum; only that I have to ascend much further; for the lowest Amphibians, as well as the whole of the Fishes, are devoid of this part of the endo-skeleton.

I want to keep entirely clear, not only of teleology itself, but also of all terms that have a teleological meaning; and this not from any disposition to depreciate that very delightful aspect of the vertebrate framework, but because I wish to treat of the *morphology* of the parts, and not of their often evident but not unfrequently obscure uses.

We cannot take a step in this department of anatomical science without a thorough acquaintance, not only with the histology of the skeleton, but also with that of the rest of the tissues that go to make a vertebrate animal.

It will be necessary to keep the histology of these parts very much in the background, however, partly for want of space, and partly also for fear of breaking the thread of my argument by introducing too much collateral material.

I must state, notwithstanding, that as much labour has been spent in making most accurate histological observations as in dissecting and depicting the grosser tissue-masses that form the Sternum and the Shoulder-girdle.

The relation of histology to morphology gives rise to the want of a few new terms for the varieties of the ossific process (*ostosis*): for these I am indebted to Professor Huxley, the "man of my counsel" in matters of this kind.

The morphological nomenclature will be found to be extremely simple, and based entirely on human-anatomy terms. These will merely be modified by having distinguishing prefixes fastened to them.

I hope to be able, by keeping strictly to the description of what I have seen, by describing the structures in an ascending manner—*i. e.* from the lower vertebrate type to the higher—by treating histology for the time as a handmaid and not as an equal, and by keeping clear of all mention, even, of the use of the parts, to transplant the roots of my ideas into the mind of my readers.[1] If I can thus show the relation of the parts to each other, their varied modifications in the ascending series, and the place they occupy correlatively to the skeletons of which they form a part, I shall have done a real service to science; for if this slow painstaking method of comparing form with form result in the discovery of the real nature of the parts, it will lead to more and better work from younger hands and fresher minds.

It will be better, it seems to me, to give the results of my own work than to keep "rounding about" amongst the theories that have been already propounded: so that it will be my work to say where I have found the scapula, for example,—and not to say who called it a "pleurapophysis," or who put it amongst the sternal ribs and called it a "hæmapophysis."

Before entering upon special description it will be well to say a few words on the skeleton generally.

The vertebrate animal has its framework developed from several sources: firstly, from symmetrical cartilages which appear at first on each side of, and in close proximity to, the absolutely azygous notochord—these are developed upwards over the spinal cord, and downwards over the viscera; and in the head they are developed *forwards* to form the greater part of the skull and much of the face: this is the axial skeleton.

Secondly, many cartilages are formed between the axial skeleton and the skin; these are—

A. The labial cartilages;
B. The sense-capsules; and
C. The fins or limbs.

The latter may lie in the vertical line, as the roots of the vertical fins of Fishes; or on the sides of the body outside the vertebral arches, as the lateral fins or limbs proper.

The Sternum is nothing else than the lower part of certain of the costal arches—a part in which the segmentation, which is so perfect in the region of the notochord, dies out more or less, and only perfectly revives afterwards in the growing young of the highest vertebrate types.

The Shoulder-girdle, like the Hip-girdle, is composed of two halves, each of which is the *root* and *foundation* of the limb of the corresponding side, and it is subject to the same law of vertical and transverse fission as the limb itself, which is merely its divergent and freer continuation.

Altogether, the cartilaginous skeleton may be called the endo-skeleton; and its division be into *axial* and *accessory*. The limbs, both root and branch, belong to the latter category.

There is also, ancillary to the cartilaginous, a fibrous skeleton, of almost equal importance, in some cases, to that which is formed of true hyaline cartilage.

This is the skeleton of the skin and its infoldings,—the exo-skeleton; and prior to ossification it is entirely composed of fibrous connective tissue in a more or less developed state.

[1] "For it is in knowledges as it is in plants: if you mean to use the plant, it is no matter for the roots; but if you mean to remove it to grow, then it is more assured to rest upon roots than slips: so the delivery of knowledge, as it is now used, is of fair bodies of trees without the roots—good for the carpenter, but not for the planter. But if you will have sciences grow, it is less matter for the shaft or body of the tree, so you look well to the taking up of the roots."—Bacon.

These two skeletons maintain their greatest independence of each other in the *oldest* and most generalised types of Fishes; in the newer (cycloid and ctenoid) types the correlation of the two becomes much more evident and perfect; but we must pass through all the cold-blooded vertebrates, and even past some of the lower types of the warm-blooded, before we see the greatest inter-dependence of these diversely developed structures.

In working out the morphology of the Shoulder-girdle and Sternum, the various modes of ossification have cost me much histological labour; taking counsel on this subject,[1] I have determined to call that ossification which commences in the intercellular substance of hyaline cartilage "endostosis."

That bony matter which is first found in the almost structureless, inner layer of the perichondrium, in immediate contact with the outermost cartilage-cells, is formed by a process which may be called "ectostosis."

Such a bony formation as appears primarily in the skin, in the subcutaneous fibrous mesh, or in the aponeurotic tracts, may be called "parostosis."

All these modes have to be most carefully traced backwards to their earliest appearance, otherwise the study of osseous centres is most perplexing; for one of the constant results of ossification in the higher classes is the coalescence of parts morphologically separate.

Nothing, however, can exceed the study of *segmentation* in importance and interest. Without a clear notion of that process in all its modes and degrees, the anatomist's ideas will keep in a hopelessly confused state.

Cartilage, as every one knows, is a very fast-growing tissue; tending to develop itself in an unstinted manner over many morphological regions at once, and only showing the proper territories by the law of segmentation, which law is potent in very various degrees in different parts, and in the corresponding parts in different types of vertebrate creatures.

Fission of, or the formation of two or more osseous centres in the same tract of, hyaline cartilage are the two kinds of segmentation to be observed; but they both have the most varied degrees of development.

If a fissure be open at one end only in a plate of cartilage it is called a "notch;" if closed at both ends, and dilated so as to form an oblong, oval, or round space, it is here called a "fenestra;" when the cleft is complete we have a true joint; this may have a "synovial cavity," or be merely a fibrous tract—the lowest kind of joint.

All these open spaces in cartilage are the result of development, and may be called *secondary* in relation to those which are to be found at the mid-line, both above and below; and which depend upon imperfect coalescence of symmetrical cartilages.

Both the Sternum and the Shoulder-girdle have these *primary* notches and fenestræ, which are not to be classed amongst *clefts*, but agree with the upper and lower "fontanelles" of the primordial skull.

Morphological territories are also measured out in another way than by the formation of perfect, or of more or less imperfect clefts; namely, by two or more centres of ossification appearing in an undivided tract of cartilage.

We are all familiar with this nascent segmentation in the limbs and limb-girdles of Man and the Mammalia generally; in the long bones the chief part or *shaft* commences to ossify very

[1] With Professor Huxley.

early by "ectostosis;" "endostosis" being set up afterwards to finish what the first process began. The ends and certain outstanding snags of these long bones ossify very late by *central endostosis:* these, I am bold to say, are arrested segments, which soon fall back, as it were, into the main part.

The cartilaginous plate may have two or more ectosteal territories in it, as we see in the human "pelvis;" and there no one doubts the morphological distinctness of these self-evident regions: another pertinent instance is the Sternum of the common Fowl and that of the Ostrich.

A feebler mode of merely osseous subdivision is where all the bony tracts are at first, and in some cases persistently, merely endosteal deposits; this is well seen in the Sternum of Lizards, where the ossification is permanently arrested; and in Birds generally, with the exception of those mentioned above (Gallinæ and Struthioninæ), where the ossification commences as in the Lizards, but runs a rapid course, and acquires an ectosteal layer before its completion.

On a subject so complex the observer is glad to find as many waymarks as possible; I think that the above are true and safe, and that by patient observance of them the variously subdivided morphological territories, with their many modes of enclosure, may be surveyed and mapped correctly.

The term "phalanges" for the joints that form the whole limb and its root is too special; "rays"[1] would be better, and when required can be used with this caution, namely, that they be not confounded with the cartilaginous rays which proceed from the facial and branchial arches in Plagiostomes, nor with those which become segmented from the ribs in some Lizards (*e.g. Hatteria punctata*), in Crocodiles, and in all Birds save the Palamedeas. All these latter rays belong to the *axial* skeleton; and the theorists generally have imagined a simplicity and a uniformity which is not to be found in nature, and have confounded these two different classes of rays.

In naming the "rays" that form the Shoulder-girdle, the prefixes, *super-*, *præ-*, *meso-*, *epi-*, &c., will suffice to distinguish the territories to be found in the "scapula" and the "coracoid:" in the Sternum a similar simplicity will characterise the terminology.

Being compelled, from the nature of my work, to show a large number of *instances*, the necessity for a copious supply of "subjects" has been great; these, however, have come to hand most opportunely, for my kind friends have helped me very liberally.

Amongst these I must mention Professors Huxley, Rolleston, and Rupert Jones; Mr. Flower and the Council of the College of Surgeons; Mr. Bartlett; Mr. Henry Power, Drs. Günther and Murie, Mr. St. George Mivart, Mr. Swinhoe (H. M. S. Consul, Formosa); Mr. E. Christy; Mr. Tegetmeier; and Mr. T. J. Moore[2] (of Liverpool); but some of the best materials of all have been put into my hands by my friend Mr. Waterhouse Hawkins,—these were principally large Reptiles.

[1] I hope never again to use that mischievous word "apophysis," with its ninety-and-nine prefixes; it was a cloudy and dark day for anatomical science when the transcendentalists, "with their enchantments," brought this swarm upon the land.

[2] In a rich supply of *Guano-mummies* of the Booby and Cormorant, from the Chincha Islands, given me by Mr. Moore, I first found the complexity of the Bird's "furcula," and was hence excited to work out the whole subject (see 'Zool. Proc.' for June 28th, 1864).

ON THE SHOULDER-GIRDLE OF THE FISH-CLASS.

As the lowest or Suctorial Fishes have neither limbs nor limb-girdles, I must begin with the most generalised forms that possess these structures. It will be very convenient to consider the endo-skeletal or essential parts first, where they are not only present in the greatest mass and quantity, but also in that Order of Fishes in which there is no correlation of the exo- with the endo-skeleton; these are the Plagiostomes or Placoids; the Rays and Sharks. Then I intend to show how the internal skeleton of these parts is put into close relation with the large "ganoid" plates that cover the body in certain types; and which plates have to be described in connection with the parts of the essential Shoulder-girdle: we have this correlation in the Sturgeon, which has a soft endo-skeleton; and in the Siluroid *Callichthys,* which has a hard one.

Then we shall come to forms in which only the inner (*subcutaneous* or *aponeurotic*) parts of these scales are, as a rule, developed in immediate contact with the true Shoulder-girdle. This is the case in the ordinary (Teleostean) Fishes; but I shall pass to the typical through a series of aberrant forms; beginning with the most generalised of all, namely, the Lepidosiren. There is no Sternum to be described in the Fish-class; my work here, therefore, lies entirely with the Shoulder-girdle.

Pisces placoidei.

A. No splint-bones; Shoulder-girdle with large supra-scapulæ entirely segmented off from the scapulæ.

Example.—Raia clavata, Linn.

In Plate I, figs. 1—4, the Shoulder-girdle of the Thornback-skate (half-grown) is shown, of the natural size; whilst fig. 5 gives a view of a small part of the surface, magnified so as to show the small, polygonal, bony plates that give strength to the cartilage. Before describing the morphological characters of these parts, it may be said that these plates are not formed by ossification of the inner, soft layer of the tough, fibrous perichondrium, but small territories of the surface-cells of the hyaline cartilage undergo immediate metamorphosis into bone: this I propose to call "superficial endostosis;" the other process, or that *outside* the cells, but taking place in the inner part of the perichondrium, may be called "ectostosis."

In one sense, this my first example is the most perfect Shoulder-girdle in all the Vertebrate Sub-kingdom; but massive and complete as it is, being the foundation of two exorbitantly large limbs, it is yet *low* and *generalised* in its morphological characters. At first sight it appears to be an absolute girdle; but upon closer inspection it is seen that the cervical vertebral spine is closely wedged between the supra-scapulæ (s. sc.), just as in the Bird the sacral vertebral spine is wedged between the iliac crests, the hinder counterparts of the supra-scapulæ. In that

Class, however, the Hip-girdle—so closely isomorphic of the Shoulder-girdle of the Skate in its fixity above—is seldom perfect below; the exception to this is that of the African Ostrich (*Struthio camelus*).[1]

The supra-scapulæ (s. sc.) of the Thornback are separated from the scapulæ (sc.) by a complete transverse cleft, which results in a perfect joint-cavity, the highest type of segmentation. Each supra-scapula (fig. 1, s. sc.) is irregularly four-sided, its upper edge straight, its anterior concave, its posterior margin sigmoid; whilst the scapular margin has an oblique convex outline, the scapula (sc.) mounting upwards behind it. The supra-scapula is thick below, and thin above (fig. 4), and by this its thin margin it is attached by strong fibrous tissue (there is no joint-cavity here) to the jutting edge of the vertebral spine: it is gently concave above (fig. 4), and as gently convex below.

The scapula (sc.) can only be distinguished from the rest of the Shoulder-girdle by an eye experienced in these structures in the higher types of Vertebrata: once seen, however, in the light of the nobler Classes, it reflects back a ray of the purest kind upon the morphology of the scapulæ of those creatures which at first illustrated it. Beyond the premature segmentation of the supra-scapulæ from the scapulæ, there is nothing but abortive efforts at division, and the histological state of these structures gives no waymark to the anatomist. The limb of one of the higher Classes of Vertebrates may be compared to an espalier tree, with thick roots in the ground—a single stem, at first bifurcating, and then breaking into its ultimate branches; but the limb of the Skate is like such a tree, rich indeed in free, dividing branches, but starting from the very ground itself with several "leaders."

Fig. 2 shows three oval, smooth, *synovial* convexities (gl. 1, 2, 3), all lying in nearly the same horizontal line; and, whilst the outer ones are vertical, the inner is directed transversely; these are the three "glenoid" facets, and they articulate with the three "brachial" concavities.[2] (See Huxley and Hawkins' "Atlas," pl. xi, fig. 9.)

The form of the scapula (fig. 2, sc.) is the reverse of what we have in Man, for the "neck" is here of great width, and the "blade," where it joins the supra-scapula, is narrow; this upper part overlaps the supra-scapula behind, its concave edge going beyond the convex edge of the upper plate. It widens gently in front, and the selvedge reaching from the supra-scapula to the front glenoid facet (gl. 1) is scarcely convex: behind, however, its outline, which is elegantly concave above, and then vertical below and behind, is directed at first more backwards than downwards.

[1] Here I may at once remark that the Hip-girdle is always, in the higher Classes, more complete as to mere mass, and lower in type, morphologically, than the Shoulder-girdle; so that whilst this part in the Skate illustrates that in the Bird, in like manner the Shoulder-girdle of the Frog is no inaccurate representation of the haunches of a Man.

[2] The mistake of making the "carpus" of the Fish articulate with the glenoid facets arose from a misapprehension of the nature of the proximal bones of the fin. Cuvier called the clavicle of the Osseous Fish "humerus," the scapula "radius," and the coracoid "ulna." Professor Owen called the clavicle "coracoid," the scapula "ulna," and the coracoid "radius." (See 'Owen's Lect. Comp. Anat.,' vol. ii, pp. 117—126.) I have already challenged the whole of this nomenclature. (See 'Zool. Proc., 1864,' part iii, p. 341.) As the *generalised* condition of these fin-rays makes it difficult to compare them with the limb-bones of the air-breathing Classes, I have adopted the term "brachial," so as to leave the question of their special homologies open.

The oblique and vertical parts of the posterior margin of the scapula meet at less than a right angle, so that this part projects upwards (fig. 2, sc.). Half-way down, this rapidly widening scapula breaks into three bars; and these form three regions, namely, the "præ-," "meso-," and "post-scapular" regions; the two outer are each twice the breadth of the inner. These are differentiated by that process in the metamorphosis of the primordial skeleton which may be termed "cleavage;" and if this process had been perfect in the Skate, there would have been a division, vertically, into parallel rays; besides the transverse cleft which separates the supra-scapula from the scapula. When, however, this process is arrested, at one end we have a "notch;" when at both ends we have a "fenestra," for this closed space does not continue a mere chink; but the expansion by growth of the cartilage causes it to become a more or less broad "window" in the cartilaginous plate: it is generally oval in shape. Three such "fenestræ" are shown in fig. 2; the front one belongs principally to the scapula, and also to the coracoid (cr.) beneath—this is the "coraco-scapular fenestra" (c. s. f.). Behind this there is a somewhat wider space, which belongs wholly to the scapula, being above the glenoid facets; this is the "scapular fenestra" (sc. f.). Below this there is a rather strong bar of cartilage which connects the second and third glenoid facets; it is almost horizontal, but dips a little behind: this may be called the "glenoid commissure" (gl.). Below this rod there is a somewhat smaller, narrow-oval fenestra, which belongs wholly to the coracoid region: this is the "coracoid fenestra" (cr. f.). The outer face of the scapula is scooped (fig. 2); and whilst the middle glenoid facet (fig. 1, gl.) projects laterally to nearly the same line as that in front (gl. 2), the posterior facet (gl. 3), like the rest of the hinder part of the Shoulder-girdle, projects to some considerable distance further outwards (figs. 1, 2, and 3, gl. 3). Where the scapula and coracoid run insensibly into each other in the glenoid region they are both at their greatest breadth; the latter part (cr.) narrows rapidly to its lowest part (fig. 2). The extension, to some slight degree, of the coraco-scapular fenestra (c. s. f.) into the coracoid region in front, and the presence of a true coracoid fenestra (cr. f.) in the hinder half, makes the coracoid in some degree trifid; the front part is the "præ-coracoid" (p. cr.); the middle bar, which underprops the middle glenoid facet, is the "meso-coracoid" (m. cr.); whilst the broad bar which runs up to the hinder glenoid facet is the "post-coracoid," or "coracoid-proper" (cr.): all these parts will reappear in the higher classes with more or less distinctness; and I promise to prove that there is nothing unmeaning in these "fenestræ" and bars; and that teleology need not be called in to show the "why and wherefore" of their existence. Each great coracoid is bent upon itself at an acute angle at the eighth of an inch below the transverse coracoid fenestra (figs. 2—4); and the cartilage, which is sixteen lines broad at the glenoid region, becomes three lines only where it meets and coalesces with its fellow of the opposite side.

The union of these two halves is absolute (figs. 3 and 4, e. cr.); there is no stoppage of the ossification at the mid-line, and no thinning down of the cartilaginous bar (fig. 4, e. cr.): the lower part of the Shoulder-girdle is formed by the "epi-coracoids" (e. cr.), here most massive, but reappearing in the higher types as thin-edged, free plates. The great, common epi-coracoid bar is rounded above (fig. 4), somewhat concave at the mid-line and with round thick edges below: the arcuate anterior and posterior outlines of this bar, as it spreads out to lose itself on each side in the upper coracoid region, are very beautiful, and so is the whole arch—Nature's own masonry!

B. No splint-bones; supra-scapulæ as small tubercles, half-segmented from the scapulæ.

Example.—Squatina angelus, Dumeril.

In the 'Osteological Catalogue of the Hunterian Museum' (Roy. Coll. Surg.) the reader will find no mention of an entire skeleton of the Monk-fish, but there has been a perfect one (prepared by the author of this Monograph) added to the Museum since the publication of that Catalogue.

This preparation shows how massive the Shoulder-girdle is in this connecting link between the Skate and the Shark—on the whole it agrees most with the former; but the supra-scapula is a mere semi-detached knob, which is articulated loosely with the spine; and there is only one fenestra in the base of the scapula, and running a little, perhaps, into the head of the coracoid. I shall call this simply the "scapular fenestra," as it is evidently the counterpart of the supero-posterior fenestra of the Skate (Plate I, fig. 2, sc. f.). We shall see it again in Class after Class as we ascend the scale. The scapula of *Squatina* is not high, but it becomes very broad where it passes into the massive coracoid; this latter part turns inwards at less than a right angle, and the transverse, or epicoracoid part, by union with its fellow of the opposite side, forms a strong subthoracic beam, in which there is no sign of the original division, either by thinning down of the bar, or by arrest of the dense pavement of polygonal bone-grains.

C. No splint-bones; supra-scapulæ as long styloid bars, only distinguished from the scapulæ by an arrest of the bony pavement over the tract where segmentation should have taken place.

Example.—Galeus vulgaris, Cuv.

The skeleton of the Tope, or smooth Dog-fish, in the Hunterian Collection ('Osteol. Catal.,' vol. i, p. 92, No. 397), is somewhat the worse for its age, but there is a fresher skeleton (made by the writer) which has been added since the printing of the Catalogue (1853). In that specimen the Shoulder-girdle of *Galeus* may be studied. There is a figure in Huxley and Hawkins's 'Atlas' (1864, plate 11, fig. 10), of the Shoulder-girdle of this species; it is a side view, and shows the upper part well; but the epicoracoid is foreshortened, and its union with its fellow is not represented. Moreover, the wrinkled condition of this, as of all *dry* skeletons of the Plagiostomes has obscured the view of the "scapular fenestra." This passage may be found, however, even in the dry preparation; the shaded *fossa* in Mr. Hawkins's figure, close behind and above the letter *a*, represents a valley which leads to it; it is small, oval, and nearly vertical, and divides the base of the scapula into a scapula proper and a præ-scapula, as in the Monk-fish and the Anourous Batrachia (see Plate V, fig. 15, sc. f.).

Mr. Hawkins's figure well shows the relation of the pointed supra-scapular "horns" to the scapula, and the obliquely transverse band of unencrusted cartilage which separates the two regions; a similar band, but smaller, marks the boundary-line between the scapula and coracoid.

The epicoracoids of *Galeus* thin-out considerably; they are very thin where they unite, and bend on each other in the dry preparation; moreover, there is no bony crust on their edges, the whole of the cartilage continuing soft for a few lines outwards.

I may remark, before passing on to the Ganoids, that the abortive development of the supra-scapula in *Squatina* is very interesting; for this part is altogether indistinguishable in the Lepidosiren and in the Teleostei; the absence of a transverse cleft between the supra-scapula and the scapula in *Galeus* is a morphological character so constant in the Vertebrata, generally, that the Rays and Sturgeons are, as far as I know, the only Families which are exceptional in this respect. I shall show that even the Frogs and Toads agree, in this part of their Shoulder-girdle, with the Dog-fish (*Galeus*), and not with the Ray and the Sturgeon. It is evident that, in using morphological "cleavage" as a measure of height in the vertebrate scale, we must be very cautious how we apply the rule, and not forget what striking exceptions there are which, in some considerable degree, diminish its value.

Pisces ganoidei (*A., Recent forms*).

A. Large dermal ("ganoid") plates covering the head and various parts of the body, many of which are correlated to the feebly ossified endo-skeleton as splint-bones; true Shoulder-girdle entirely unossified.

Example.—Acipenser sturio, Linn.

If the anatomical student has well considered the perfect independence of the endo- and exo-skeleton in the Placoid Fishes, he will be in a state of mind fit to receive the intelligence which the study of the Sturgeon will impart to him. Here the endo-skeleton is largely developed, but for the most part unossified, and arrested as to *type;* the ossification also, when it does occur, as on most of the cylindrical cartilages, is as a sheathing "ectosteal" layer, which invests the cartilage for a long time before setting up "endostosis" within; this is in harmony with what is found in the embryos of all the Teleostei, and in the adult Fish in some instances, *e.g. Gobius minutus,* Linn. But in the region of the body treated of in this Memoir we find no ossification whatever; and therefore the relation of the exo- to the endo-skeleton is very easy of interpretation.

Here commences a remarkable organic affinity of the "bars of the skin" for the bars of the flesh; the former, in certain regions, cleaving to the latter as the bark of a tree does to the wood, or as the ivy does to the trunk that supports it; and, like the ivy, the *splint-system* seems to injure what it protects, for in many instances there is an evident abortion of the endo-skeleton as a correlate of the overgrowth of the outer bony plates, as may be seen in the trunk of the Tortoise. *There* the affinity of the outer for the inner skeleton is intense; *here,* in the Sturgeon, it is less pronounced; ultimately, in the warm-blooded classes, we shall see that parts of the exo-skeleton do actually *graft* themselves upon parts of the endo-skeleton, as the Mistletoe grafts itself upon a dicotyledonous tree.

But there is nothing *loose* or *accidental* in the manner in which the strong "ganoid" plates of the Sturgeon apply themselves to the soft inner parts; and having once determined the true homologies of those endo-skeletal regions, we can also be sure of their dermal correlates in Order after Order and Class after Class, until we reach even our own species; the genesis of the vertebrate skeleton being thus traceable from the low, *larval* Ganoid Fish up to its continuation in the human being.

The supra-scapula of the Sturgeon (Plate I, figs. 6 and 7, s. sc.) is a thick trihedral plate of soft cartilage; it is expanded on its postero-external surface, against the overlying dermal plate, and anteriorly grows forwards as a thick plate, somewhat convex within (fig. 7), and very concave externally (fig. 6); its outline is that of a gooseberry-prickle, only inverted in position, and blunt-pointed; it is wholly segmented from the cartilage below. The lower surface is directed backwards and downwards; it is scooped into an oblong articular cavity, to receive the convex head of the scapula, which fits into it as the humerus fits into the ulna in our own skeleton.

The rest of the Shoulder-girdle moiety is not easy to describe (see figs. 6—8), for it contains the coraco-scapular mass in a very primordial condition, both histologically and morphologically; it is like a mass of clay rough-modelled by the hands of the potter, but ready to become the shoulder-blade of any kind of vertebrate creature whatever, as it shall " seem good to the potter to make it." The general form may be described as an oblong trihedral bar; bifurcate below, and attenuating into a thin edge wherever it comes into contact with the dermal plates: its surfaces are sinuous; now convex; and anon gently scooped. Above, it is narrowed, as it rises in front into the highest and broadest part of the supra-scapular concavity; it steadily broadens downwards, and then becoming of great width and thickness has all the centre scooped away, a large elegantly arched viaduct being formed, which looks from before backwards (Plate I, fig. 8, sc. f.). The floor of this archway is deeply scooped, and through it, towards the outside, there is an oval false (membranous) floor (fig. 6, c. s. f.). The inner wall of the archway is very thick (fig. 8, p. sc.), the outer (fig. 8, sc.) is much thinner; the hinder, broad end of the floor is very thick, and it has scooped in it five glenoid cups for the *brachial* series of cartilages: these depressions lie in an arcuate line which turns downwards, behind (fig. 8, gl.); they are filled with fine fibrous tissue, a species of joint existing here like what we shall see in the Cetacea. The concavity of the floor of the archway becomes narrow in front and is then lost (fig. 7, upper part of p. cr.); the cartilage here growing forwards and a little downwards as a distinct fork; it is broad, flat within (fig. 7, p. cr.), and expands externally and in front into a thin-edged disc, which is slightly concave on the outside, where it adheres to the semi-transparent dermal bone (cl.), like the " foot " of a Snail upon the window-pane. The main part does not alter its direction or character (fig. 7, cr.), but ends abruptly below with a rather sharp edge (figs. 6—8, cr.): it sends upwards on its outer side a sharp lamina (e. cr.), which also, snail-like, applies itself to the dermal bone outside of it. (i. cl.) This is the cartilage, the interpretation of which must be made sure, or we shall lose the first fastenings of our argument. If a transverse line be drawn through the middle of the " glenoid " facets, we shall see how far down the scapula extends: all below is coracoid. But the thick inner wall of the great archway is in *front* of the thinner outer wall; the former is the præ-scapula and meso-scapula (p. sc.) in one half-cleft ray; the latter is the scapula proper (sc.), and answers to the hindermost bar in the ray (Plate I, fig. 2, sc.). The floor in front of the glenoid facets is common to the scapula and coracoid, and the snail-footed bar in which it terminates is the præ-coracoid (p. cr.): the false, or membranous floor, is the coraco-scapular fenestra (fig. 6, c. s. f.), and answers to the front fenestra in the Skate (fig. 2, c. s. f.). The creeping foot at the lower part of the coracoid is the epicoracoid (e. cr.): it is but little developed towards its fellow of the opposite side, and is thus very unlike the epicoracoid of the Skate (Plate I, figs. 2 and 3, e. cr.). Opposite the bifurcation for the epicoracoid there is seen, behind and within, the coracoid foramen (fig. 7, c. m.), that is, its *entrance*: its *exit* may be seen in the fresh cartilage below the largest glenoid cup.

It will be seen from the above description that, on the whole, I agree with Professor Owen as to the *special* homologies of the Sturgeon's Shoulder-girdle (see his 'Lect. Comp. Anat.,' vol. 2, p. 131, and 'Osteol. Catal. Mus. Coll. Surg.,' vol. 1, p. 83, No. 374); but I am not aware whether or no he considers this as an instance of the articulation of the supra-scapula with the lateral occipital region; if so, then I must be allowed to differ from him. In the work first cited ('Lect.,' p. 131, fig. 43) the dermal bone (d. 50) is a splint of the supra-scapular cartilage (50), and articulates with the great supra-temporal plate (d. 8), as is well shown in Huxley and Hawkins's 'Atlas' (plate 5, fig. 3 *a*); for the dermal splint of the supra-scapula is the first *lateral-line* bone, and comes next *behind* and below the supra-temporal or supra-temporals in all the Fishes that possess such bones. But, as my fig. 7 shows, the true supra-scapula (s. sc.) lies low down within the great scale that invests it, and is really as free of the occiput as its counterpart in the Placoids: I shall afterwards show *that there is no instance whatever in which the true Shoulder-girdle is articulated to the occiput.* All the confusion in this matter is due to Cuvier's misinterpretation of the first lateral-line bone (my "post-temporal scale") as the supra-scapula; and on this *nail,* which could not be driven into Nature's hard wall of *facts,* our great English anatomist hung his theory of "the Nature of Limbs."[1]

Professor Huxley, in his 'Elements of Comparative Anatomy' (1864), gives a drawing (after Müller) of the anterior part of the head-skeleton of the Sturgeon, in which the Shoulder-girdle is left out (see p. 206, fig. 83); this wood-cut shows that there has been no violence done to the head by the removal of cartilages so loosely and extraneously connected with it. On the same page we are referred to another figure (82, p. 205) in which an outline view of the dermal plates of the Sturgeon's head is given, the cartilage below being shown by shading. Here the plate *I* is called a "supra-scapular bone," and *L* the "scapula:" this seems to me to be a mistake, for the latter is the *splint* to the supra-scapular cartilage, and the former is merely a huge "supra-temporal."[2]

If the reader refers to Plate I, figs. 6—8, he will see the relation of the supra-scapular splint (p. t., "post-temporal") to the soft endo-skeletal supra-scapula within it; if it is compared with the figures in Plate II, it will be easily seen that this dermal bone is the true homologue of the so-called "supra-scapula" of the Teleostei: in them, however, there is no endo-skeletal piece in the inside; the supra-scapula being entirely absent, as far as I know, in all Fishes except the Placoids and the Sturgeons. The upper fork, and all the posterior margin of the "post-temporal" scale of the Sturgeon, is devoid of the "ganoid" prickly ridges (see figs. 6 and 8); this smooth thin part being *subcutaneous* to a great degree, or at least formed by ossification of the innermost part of the "cutis vera." The well-macerated specimen from which these drawings were made has revealed the true *scapular splint,* the bone which in osseous

[1] A Discourse delivered on Friday, February 9th, 1849, at the Royal Institution of Great Britain, and published by Van Voorst, London. Our author still refers us to this work as containing his views of the philosophy of these great questions (see 'Zool. Trans.,' vol. vi, part i, p. 45, 1866).

[2] There are several other points in the Fish's skeleton in which I differ from my friend Professor Huxley (see p. 188 of the same work; and also p. 162 of my paper "On the Ostrich's Skull," 'Phil. Trans.,' 1866).

Fishes has been supposed (by Cuvier and others) to be the scapula. As there are still two more dermal bones in each semi-girdle below the one in question, I was perplexed for some time as to which of the outer shoulder-plates I must call the scapular splint: it can, however, all be explained. Figs. 6 and 8 show this bone, which may be called the "supra-clavicle" (s. cl.); it protects the posterior face of the scapular cartilage, just down to the great scapular fenestra; and in this half-grown Sturgeon it is 20 lines long and 4 lines in breadth. This scale has a small ganoid tract along its middle, an easy step towards its entirely subcutaneous condition in the Teleostei; it is overlapped by the post-temporal above, whilst the lower half of its anterior margin articulates with the great clavicle (figs. 6 and 8, p. t., s. cl., cl.). Its counterpart in other types will be easily recognised in Plate II; but it is not clearly shown in Huxley and Hawkins's 'Atlas' (see plate 5, fig. 3*a*), for there are minor and less specialised bone-grains running behind the great shoulder-plates, and the small amount of ganoid surface which this bone possesses makes it difficult of discovery at first. In some instances I shall show that this bone is not always ossified separately from the true clavicle; but whether as a *region* or as a distinct dermal plate, its identification is of the utmost importance.

The large plate next below the "supra-clavicle" at one time beguiled me into supposing that it answered to the so-called "scapula" of authors; for it is not the lowermost bone in this series. As a large number of Mammals—including Man—possess the counterpart of the bone now under consideration, its real and relative morphology must be thoroughly mastered: it is the true "clavicle," and a knowledge of it must be made the foundation-stone of all our scientific knowledge of the structures and relations of the *outer* and *inner* Shoulder-girdle. This large ganoid plate is rough externally, where it applies itself to the outer part of the scapular and post-scapular bars; and further downwards to where it articulates to the plate beneath it (Plate I, figs. 6 and 8, cl.). It is smooth, thin, and radiating as it passes inwards, behind the operculum (see Huxley and Hawkins's 'Atlas,' plate 5, fig. 3*a*; and Plate I, figs. 6—8, cl., of this work); it is this inner plate to the convex hinder surface of which the præ-coracoid is attached, snail-like (fig. 7, cl., p. cr.): this point of relation will serve as a most capital landmark all the way along our devious journey to the shoulder of the youngest-born of the Vertebrates. Another waymark is to be seen below; for where the spreading, outer plate of this bone begins, below, to lose its ganoid character, and to be overlapped by the bottom plate there, behind, the "epicoracoid" is naked, and on the inner side of the clavicle a *part* of its snail-footed lamina is spread, the rest lying on the lower bone (see figs. 6—8, cl., i. cl., p. cr.). The eye will rest on this landmark when the complexities of the Reptilian Shoulder-girdle are being sighted.

To an anatomist familiar only with the skeleton of ordinary Osseous Fishes, the bone now to be described would be an anomaly; it is the "interclavicle" in the nomenclature of this paper; and in one form or another it will meet the eye until we are actually within the Mammalian circle. This bone (figs. 6—8, i. cl.) is equal in size to the clavicle, but its ganoid part is much broader; this part, as in the clavicle, is bent at an acute angle on the inner plate; it is oblong, and is notched in front and at its lower angle. The inner plate is, like that of the clavicle, convex behind and concave towards the operculum; it is very smooth and thin, so thin as to be fenestrate, and its outline is four-lobed. In the Sturgeon there is this instructive condition, namely, the thin, outspread lamina of the epicoracoid rests upon the upper part of this inner plate, as well as upon that of the clavicle; and this notwithstanding the *over*lapping of the interclavicle (figs. 6—8): I must recur to this when I come to speak of *Polypterus* and its fossil congeners. The præ-coracoid creeps, snail-like, to the very edge of the clavicle (see fig. 7, p. cr., cl.), but stops short there: this has its morphological meaning, and it is noteworthy how true these ganoid plates of the Sturgeon are to their endo-skeletal correlates, notwithstanding their slight specialisation from the ordinary bony plates of the body generally.

The bony grains seen behind the great dermal shoulder-plates in the Sturgeon are, with the exception of the "supra-clavicle," in a very generalised condition (see Huxley and Hawkins's 'Atlas,' plate 5, fig. 3*a*); there are none that can be specially described as "post-clavicle:" in the Ganoid Fish with a bony endo-skeleton these can be determined. It will perhaps be said that what I have described as single plates in the Sturgeon are in reality separable into an outer and an inner layer (a "ganoid" and a true skeletal part) in the embryo: to this I answer yes,—granted; but this arises from the very manner of the development of these plates, as I shall show in the case of the dermal bones of the Chelonia (Plate XII); for where a thick stratum of fibrous tissue is undergoing ossification ("parostosis"), the calcified tissue is always in laminæ, which are more or less distinct at first; these may coalesce entirely, and the bony matter grow *peripherad,* so as to leave a very thin "quick" for the equally thin cuticle, and it may at the same time grow *centrad,* working its way into the subcutaneous tissue, and shooting along aponeurotic septa. In the higher types of Fishes the bones that are correlated to the endo-skeleton are, for the most part, largely extended, separate ossifications of this inner web; whilst the *sub-peripheral* stratum is ossified from many hundreds of points; which points form the nuclei of the exquisite "cycloid" and "ctenoid" scales, that have no more special relation to the endo-skeleton than what is to be seen in the "placoid" grains and *thorns* in the skin of the Sharks and Rays.

B. Ganoids with well-ossified endo-skeleton.

Example 1.—*Polypterus Bichir,* Geoff.

In describing other instances of the Shoulder-girdle in the true Ganoids, I shall make free use of Professor Huxley's masterly Memoir on this Order,[1] referring to his figures, and endeavouring to give a correct nomenclature where the author—wise in his doubts—has left the terms in a provisional condition.

At page 22, two figures (16 and 17) are given (after Müller, but "somewhat differently named"). In the upper view the "post-temporal" plate is lettered s. s., it answers to the so-called "supra-scapula" of the Teleostei: it is a mere supero-lateral ganoid bone; the first of the kind belonging to the trunk. Articulating with this bone, by a hinge-joint, is another broad but strong bone, which has scarcely any ganoid structure, for it lies deeper; it is seen in shade in

[1] 'Memoirs of the Geological Survey of the United Kingdom,' "Figures and Descriptions illustrative of British Organic Remains," Decade 10; London, 1861. I would also refer the reader to J. Müller's work on 'Fishes,' 'Ueber den Ganoiden und den natüraliche System der Fische,' 1846. Also to the works of Agassiz, viz., his "Vieux Grès Rouge," and his "Recherches sur les Poissons Fossiles," 1844; to Hugh Miller's 'Old Red Sandstone,' 1841; and to Professor Pander's work, 'Ueber die Saurodipterinen, Dendrodenten, Glyptolepiden, und Cheirolepiden des Devonischen Systems,' 1860. Moreover, as my space does not admit of figures to all my instances, I must refer the reader to the beautiful skeletons of *Polypterus, Amia,* and *Lepidosteus* in the Hunterian Museum.

fig. 16, but the letters *sc.* are wrongly put to the bone below it. In fig. 17 it is marked *x* and *sc.*, and it is largely overlapped by the operculum (*Op.*) and in its turn overlaps the bone below it; it is not the scapula, but a subcutaneous bone, the "supra-clavicle." The bone below, which passes obliquely inside the base of the last, is the true clavicle; it is marked *C*, meaning that it is Owen's "coracoid:" it is subcutaneous, like the last; is broad at the top, and pinched at the middle; and lower down it broadens, passes inwards, becomes blunt-pointed, and is separated from its fellow by about 3 lines. On its inside, its middle third is in relation with the Shoulder-girdle proper (fig. 17, l.), which is very small, but is ossified. The lower bone (fig. 17, C^1) does meet its fellow, and it is formed by the ossification of a more external part of the skin; it overlaps the base of the clavicle, underlying it, and passing mesiad to meet its fellow: this is the "interclavicle." Now, we saw that in the Sturgeon the four dermal additions to the Shoulder-girdle moiety had all more or less of the ganoid surface besides the subcutaneous laminæ, and that the second of these—the "supra-clavicle" (see Plate I, figs. 6 and 8, s. cl.)—had very little; so now we see in the *Polypterus*, which comes much nearer the Teleostei, that only the uppermost and the lowest of these bones retain the ganoid surface. In the Sturgeon the lowest *overlaps* the one above it, and yet is in relation with the soft "epicoracoid" (see Plate I, figs. 6—8, e. cr., cl., i. cl.). But Müller's figure shows another plate (marked *y* in fig. 17); it is overlapped by the supra-clavicle (*x*) in front, and by the clavicle (*C.*) below. If the reader will refer to Professor Hyrtl's preparation in the Hunterian Museum, he will see another plate, which lies behind and *within* the one in question; this last is the "lower post-clavicle," and the bone *y* is the "upper post-clavicle." Now, if we turn to the large skeleton of *Polypterus Bichir* (marked "327 B") we shall see three succeeding vertical rows of such bones: the first row only comes under my nomenclature. The uppermost of this first row is the bone which next succeeds to the so-called "supra-scapula," or the "post-temporal:" its true counterpart is the second "lateral-line" bone of the Teleostei (see Plate II, fig. 12, l. l. 2): the middle and lower bones are the "upper" and "lower post-clavicles." Fig. 17 of Professor Huxley's Memoir has the coracoid marked *1*; the scapula, above it, is not lettered. These bones are also figured in Professor Owen's 'Lectures' (1846, Vol. 2, p. 122, fig. 41); here 54 is, in my opinion, the scapula, and 55 the coracoid. Referring to the skeletons we find that the whole moiety of the Shoulder-girdle is a small semi-lunar plate deeply notched in front (this is the "coraco-scapular notch"), and having one bony centre for the scapula, and one for the coracoid: the whole of this plate is too small to reach either the "supra-clavicle" above, or the "inter-clavicle" below; it lies inside the middle third of the clavicle.

Example 2.—*Calamoichthys calabaricus*, J. A. Smith.

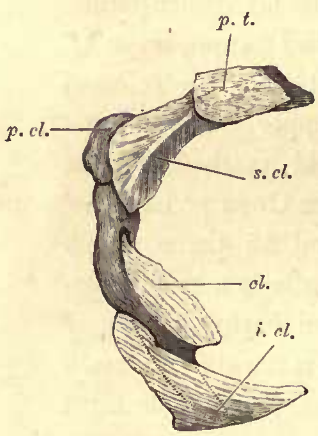
Since the above was written I have been able to obtain a specimen of this newly discovered Ganoid Fish (a sub-generic form of *Polypterus*) from Old Calabar. In the 'Annals and Magazine of Natural History' for August, 1866, pp. 112—114, there is a description of this Fish by Dr. J. Alex. Smith, with remarks upon its internal structure by Dr. Traquair.[1]

The woodcuts (p. 16, figs. 1 A, 1 B, 1 C) show the part of this Fish's structure with which I have to deal: fig. 1, A and B, magnified five diameters, and fig. 1 C, ten diameters: the entire specimen measures 8½ inches in length. The three upper dermal shoulder-plates (fig. 1 A, p. t., s. cl., cl.)

[1] Communicated by Dr. Smith, from the 'Proceedings of the Royal Society of Edinburgh.'

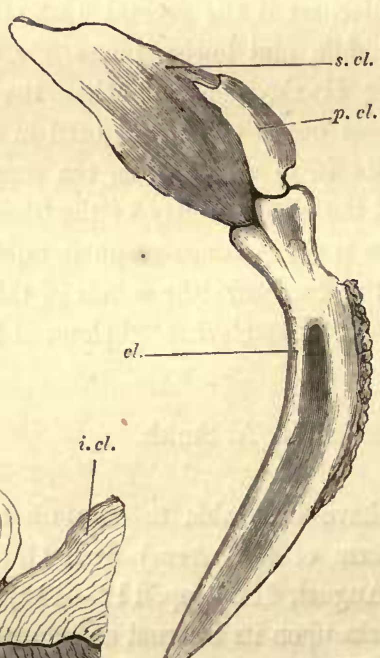
are very strong and ganoid; the post-temporal (p. t.) is strongly attached to the occiput, has a large ganoid surface, round behind, and oblique in front; and under the oblique end is a strong subcutaneous peg for articulation above. The supra-clavicle (s. cl.) is overlapped above by the last; it is leaf-like and carinate a little in front of the middle; sinuous and notched behind its blunt inverted apex, and hollow within (fig. 1 C). The clavicle (cl.) has a spatulate ganoid region which is twice as large as an ordinary scale of this Fish; but its subcutaneous part is very much larger than the exposed part (figs. A and B, cl.), is like a strong curved nail with the head split, and is strongly grooved within (fig. C). Above the hinder part of the head of the clavicle is the post-clavicle (figs. A and C, p. cl.); it is a slightly modified ganoid plate, enamelled on the outside, hollow within, notched above, and rounded below. The clavicle stands on the *inner* edge of another large ganoid plate, a little behind its middle, this is the interclavicle (figs. A and B, i. cl.). It is a most elegant plate, with three sides, the upper concave and sinuous; the hinder transverse and sinuous; the lower or submesial straight and then notched (fig. B). This interclavicle has no aponeurotic portion; it is thin, marked with ridges of enamelled elevations that run parallel with its outer superior margin, and it has its upper end (which lies a little behind and below the enamelled part of the clavicle) lobate. This plate and its fellow are the serial homologues of a pair twice as large, that lie between the mandibular rami; these beautiful lanceolate plates (fig. 1 B, ju.) are the "jugulars"—very characteristic of the Ganoidei, but occurring also in a few Clupeoid Teleostei (in *Megalops* and *Elops*, according to Cuvier), and, as I have recently found, they exist likewise in the Lophobranchii.

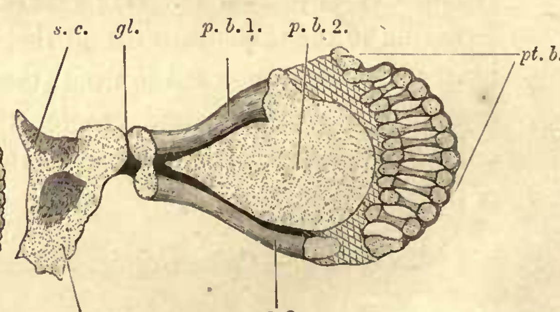
Fig. 1 A. THE SHOULDER-PLATES OF CALAMOICHTHYS.



(Magn. 5 diam.)

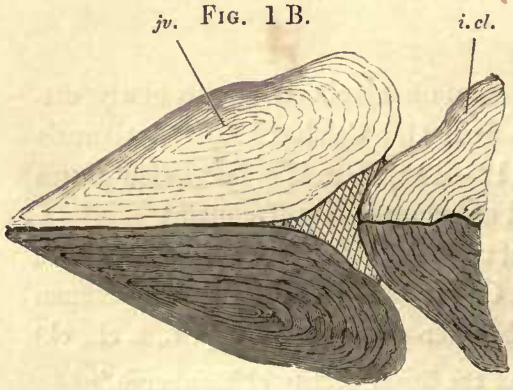
Fig. 1 C.





(Magn. 10 diam.)

Fig. 1 B.



(Magn. 5 diam.)

The coraco-scapular plate is entirely unossified, as in *Amia* and the Lophobranchii, and it has no " fenestra " (fig. 1 C, sc. cr.): there is, however, an ovoidal scooped space on the inner side. The scapular region (sc.) is pointed above, in front; behind, it forms a thick, cleft boss—the glenoid elevation and depression: below this part it gradually becomes narrower; has sinuate edges, both before and behind; and ends below in a broad three-toothed oblique margin, which is very thin. The arm-plate, altogether, is oval, with the broad end behind; its first moiety is partially subdivided into three rays—præ-brachials (see fig. 1 C, p. b. 1—3). The upper and lower præ-brachial rays are long sigmoid rods, soft at the ends, continuous proximally, the lower being the longest by one-fourth. Between these rays there is a large, pointed, oval leaf of thin clear cartilage, it is continuous with the upper ray, distally, which is lobulate where it runs into the leafy plate. At a little distance from the evenly semicircular posterior end of this flat middle præ-brachial (p. b. 2) there is a second crescentic row of post-brachial rays, thirteen in number (fig. 1 C, pt. b.). The two uppermost are unossified, as also is the lowest; the other ten are drumstick-like, with large soft ends projecting from the thin ectosteal sheaths: the distal ends are almost globular, the proximal oblongo-oval.

The uppermost post-brachial ray is obliquely spatulate, the second thicker than the ossified rays, but approaches them in form; the lowest is a low triangle, with its base upwards. Here, if anywhere, we have an instructive morphological condition; it has cost much labour to make it out thoroughly, but *alkalies* and *glycerine* have made the whole of this delicate " arm " translucent, and patience has done the rest.[1]

Example 3.—*Lepidosteus lucius,* Owen.

The skeleton of this Fish (see 'Osteol. Catal. Mus. Coll. Surg.,' vol. i, p. 82, No. 369) is well worth careful study, as it shows a still greater approach to the typical structure.

In Huxley and Hawkins's 'Atlas' (plate 5, fig. 2) there is a side view of the skull; but only one of the bones to be described by me is seen in this figure. This is the " post-temporal "—a pistol-shaped bone, the hinder of the two lying above the operculum (op.); it is a strong, thick ganoid plate, articulating with the ganoid roof-bones above and with the supra-temporals in front. The " stock " of this bone is its smooth, rounded, lower end, which fits into a cup on the outside of the top of a strong *subcutaneous,* sickle-shaped " supra-clavicle." This latter bone in its turn overlaps the large, long, lunate clavicle, which, passing downwards and forwards, meets its fellow at the mid-line without the intervention of the " inter-clavicular " pieces. The post-clavicles may be pitched upon amongst the next succeeding dermal bones, but they have very little specialisation. Here we have arrived at the typical condition of the supra-clavicle and the clavicle; but the post-temporal is still very little like that of ordinary Teleostei.

Example 4.—*Amia calva,* Linn.

In this living Ganoid there is much correspondence with *Lepidosteus* in the bony plates

[1] I should wrong my friend Mr. T. J. Moore, of Liverpool, if I were to omit to mention that he it was who pointed out to me the paper by Dr. J. A. Smith in the 'Annals of Nat. Hist.;' and, still better, where actual specimens could be procured, namely, from Mr. Gerrard, Jun.

that cover the Shoulder-girdle. A fine skeleton of this Fish is to be seen (amongst Hyrtl's preparations) in the Hunterian Museum, and in it the relations of the so-called supra-scapula are well shown. The temporo-parietal region is one mass of ganoid bone; behind this helmet there are two oblong bones, which become narrow where they meet at the mid-line; these cover the supra-occipital region. Below, and a little behind each of these, is a squarish, thick, ganoid supra-temporal; and behind this is the thick external part of the "post-temporal," the subcutaneous part of which is triangular, and passes upwards and forwards to articulate with the inner lamina of the supra-occipital *derm-bone*. The lower ganoid part of the bone overlaps and articulates with the super-clavicle; this is a lunate bone; it is subcutaneous, and its pointed lower end overlies the great falcate clavicle; this latter bone has no inter-clavicular bone between it and its fellow of the opposite side. Inside these, at their junction, the anterior edge of a flat, subcutaneous post-clavicle passes; this bone is the counterpart of the middle bone of the three described in the *Polypterus*. The coraco-scapular cartilage inside the clavicle is soft, as in *Calamoichthys*, and the seven bony rays seem, in the dry preparation, to be obliquely attached to a cartilaginous præ-brachial. I cannot satisfy myself, however, on this point.

Pisces ganoidei (*B.*, *Fossil forms*).

Example 1.—*Glyptolæmus.*

As a thorough understanding of the nature of the skeleton in the Ganoids is vital, not only to the present inquiry, but also to any investigations concerning the morphology of the skeleton generally, I shall depart from my rule of studying only recent forms, and give some account of the extinct types of this group of Fishes.

I shall refer the reader to the woodcuts in Professor Huxley's memoir (quoted above), so that, by comparison of these figures one with another, with those of recent related types, with my figures of the parts in the Sturgeon, and in the Siluroid *Callichthys* (Plate I, figs. 9—13), and also with the skeletons of the recent Ganoids in the Hunterian Museum, a clear view of the structure and relations of these parts may be obtained.

Moreover, as I have to show, not only the structure of the outer and inner (or essential) parts of the Shoulder-girdle, but also the relations that this arch has, fore-and-aft, to the rest of the skeleton, I shall be under the necessity of giving some account of parts that are not actually "in the bond."

The Ganoids generally may, in a rough way, be said to lie between the Sturgeon and the *Polypterus*, and it is of the utmost importance that the morphologist should have clear ideas respecting the structure of these diverse recent types of this Order. The degree of ossification of the endo-skeleton in the fossil genera ranged between these two extremes; but throughout there was evidently very little separation of the outer ganoid part of a derm-bone from the inner or aponeurotic portion. As to the Skull and Shoulder-girdle, these parts are not in the least ossified in the Sturgeon, whilst they have an unusual degree (for Fishes) of bony hardness in the *Polypterus;* intermediate conditions are common amongst the extinct types. In all Fishes with ganoid roof-bones to the skull there is evidently only one category of bones to be seen from the outside. In the ordinary Teleostei this is quite otherwise, for in these Fishes *ectosteal* bones of the endo-skeleton crop up and appear amongst the *subcutaneous* splints. Thus, in the common Cod-fish (*Gadus morrhua*) every one knows that the endo-skeletal "ethmoid," "præ-frontals," "post-frontals," "pterotics," "epiotics," and "supra-occipital," come up to the inner face of the skin, and articulate with the *subcutaneous* "nasals," "lachrymals," "frontals," "parietals," and "supra-temporals." In the Trunk-fish (*Ostracion*) this is not the case; but a complete helmet of hexagonal ganoid bones overlies the feeble *ectosteal* bones of the endo-skeleton, and the generally feeble, subcutaneous (*parosteal*) plates that belong to the exo-skeleton.

Now, these latter may be separate in the *Polypterus;* I believe they are not; but if they are, still the bones labelled *So.*, *Ep.*, *Pr.f.*, and *Eth.*, in the figures given by Professor Huxley, and just referred to (op. cit., p. 22, figs. 16 and 17), are not the supra-occipital, epiotic, præ-frontal, and ethmoid, but merely dermal bones overlying those regions, and which in different types may or may not have endo-skeletal bones beneath them. As for the dermal bones, such as the frontals and parietals, they may be separate from the outer ganoid plates, as in *Ostracion;* or connate with them, as in the Sturgeon. All these things must be considered before the cranial helmets, and the overlying bones of the Shoulder-girdle in the extinct Ganoids can be understood.

The reader may make himself certain that *all* the bones which can be seen from the surface on these Ganoids are *dermal*, and it is also probable that the Shoulder-girdle and Skull were very often not ossified at all; in many cases not more than is to be seen in the Trunk-fish (*Ostracion*), and in the Lump-fish (*Cyclopterus*); very seldom would the endo-skeleton come up to the hardness seen in the recent *Polypterus.* Holding these things in memory, we will refer to fig. 2, p. 2, of Professor Huxley's Memoir, which shows in a diagrammatic form the ganoid plates that cover the skull, face, and shoulder of *Glyptolæmus.*

The plate marked *Eth.* is a ganoid scale covering the endo-skeletal "ethmoid;" those marked *Pr.f.* and *Pt.f.* likewise cover the præ-frontal and post-frontal regions; but do not answer to those bones in the Teleostei. Both *Pt.f.* and *Pt.o.* belong to the same category, and arise from the bifurcation of the supra-temporal series; for the "lateral-line" series, even in the Teleostei, forks over the temples, to surround the eye; the super-orbitals going over the orbit, the sub-orbitals below, whilst the præ-orbital (or lachrymal) closes in the series in front. (See on this subject my paper on the "Osteology of the Gallinaceous Birds and Tinamous," 'Trans. Zool. Soc.,' 1863, vol. v, p. 212; and another on the "Ostrich's Skull," 'Phil. Trans.,' 1866, vol. clvi, part 1, pp. 177, 178.) The bone marked *Sq.* is not the "squamosal" (see my views in a note to Prof. Huxley's 'Elem. Comp. Anat.,' p. 188), but the second supra-temporal; the bone marked *Ep.* is the first (hindermost) of this series, and overlies the true epiotic bone or cartilage. The next behind *Ep.* is the so-called supra-scapula, my "post-temporal"; and the bones behind that belong to the second thoracic-dermal cincture, some part of which is almost constantly seen in the Teleostei as the post-clavicular series. *S. o.* is the single ganoid counterpart of the supra-occipital splint; I have it in the skull of a species of *Anolis* from Barbadoes, and it is constant, but symmetrical in the Mammalia, lying above the true supra-occipital; but of course it only re-appears as a subcutaneous bone in them. *Pa.*, *Fr.*, and *Op.* are rightly labelled, as these do truly represent the parietals, frontals, and operculum. Professor Huxley is right (p. 40) in doubting the preopercular nature of *P. o.*; it is the suboperculum, which may be seen running up in front of the operculum in *Polypterus* (op. cit., fig. 17, *S. op.*); and in *Lepidosteus* (see Huxley and Hawkins's 'Atlas,' plate 5, fig. 3, *S. op.*). In the left-hand figure the bone which comes close behind the mandibular ramus is labelled *S. op.*, or suboperculum; but if the reader will again refer to the figure of the *Lepidosteus* in the 'Atlas,' he will see that the "inter-opercular" bone, which in all Osseous Fishes is tied by a strong ligament to the angle of the lower jaw, is a large, long, ganoid bone, lying at the precise distance behind the angle of the lower jaw which is given in the diagram of *Glyptolæmus*. If the "jugulars," *J* 1 and *J* 2, were to send inwards and upwards ossified aponeurotic plates, these would answer to the "splenial" and coronoid plates that lie on the inside of "Meckel's cartilage" in Birds, Reptiles, and Sauroid Fishes. The ganoid plates indicated by *M. R.* in the diagram are the dentaries; and the symmetrical plates which grow towards each other behind the great jugulars (*Pct.* 1 and 2) answer to the "inter-clavicles" and lower "post-clavicles." The former are lettered *C'* in fig. 17, p. 22, in the *Polypterus* in that oft-quoted memoir; the latter have their counterparts in the Herring. (See Plate II, fig. 6, p. cl. 3. Also represented in the lower half of the second infero-lateral plate of *Callichthys*, Plate I, fig. 9, p. cl.)

Example 2.—Osteolepis.

The restoration of *Osteolepis*, which is given (from Pander) in the same memoir (p. 11, fig. 8), shows a "post-temporal" scarcely larger than the "supra-temporals," which are seen running from the post-temporal to the orbit; the front bone of that series articulates with the last suborbital—it is the post-orbital. Below the "post-temporal" is an enormous "supra-clavicle;" below it an almost equally large "clavicle;" and below that, and behind the jugular plate, we see the "inter-clavicle." The *fringed* and elongated pectoral fin is seen emerging from its hidden root behind the junction of the clavicle and inter-clavicle: that root, the Shoulder-girdle moiety, or "coraco-scapular cartilage," was probably never ossified.

Pisces dipnoi.

Example.—Lepidosiren annectens, Owen.

For Professor Owen's descriptions of the anatomy and relationships of this unique type of Fish, I refer the reader to the following works,—'Proc. Linn. Soc.', August, 1838, and April, 1839; 'Ann. of Nat. Hist.,' 1839, iii, p. 265; 'Rev. Zool.,' 1839, p. 190; 'Linn. Trans.,' xviii, p. 237; 'Ann. and Mag. Nat. Hist.,' 1841, vii, p. 358; 'Lect. Comp. Anat.,' 1846, vol. ii, pp. 78—84; 'Nature of Limbs,' 1849, p. 92; 'Osteol. Catal. Mus. Coll. Surg.,' 1853, vol. i, Nos. 380, 381, pp. 85—89. For Professor Huxley's account of the affinities of Lepidosiren the reader must consult his 'Memoir on the Ganoids,' p. 26.

My dissections of the Shoulder-girdle of this fish are portrayed in Plate II, figs. 1—3; the figures represent the parts as magnified three diameters, and the specimen (the gift of Mr. Bartlett) was half-grown.

Referring to these figures, it will at once be seen that there are more things in this limb-girdle than a pair of scapulæ and a pair of coracoids, and that the limb will keep its place even if the "occipital pleurapophyses" be not regarded. (See 'Osteol. Catal.,' vol. i, No. 381, p. 86.) Fig. 1 b. o. represents part of the basi-occipital cartilage; e. o. part of the "ex-occipital;" pa. s. the termination of the "para-sphenoid" (of Huxley); p. b. 1 the large first "pharyngo-branchial," which is well ossified as a shaft-bone; and p. b. 2 the small, unossified second "pharyngo-branchial."

As to these *autogenous* upper parts of the first and second branchial arches, I claim the discovery of the second bar. With regard to their nature, it will be remembered that Professor Huxley, in his 'Elements,' p. 208, left that undecided, but described the large bar in fig. 84, where it is lettered *y*, as "the bone which gives attachment to the scapular arch." Afterwards, in conversation with him, when, after the examination of a much decayed specimen, I hinted that it might be a separate "supra-scapula" (as in the Sturgeon), he at once combated that view, and suggested that it might belong to the first branchial arch. That was a true insight into its nature; for it has, as the figure shows, another weak bar attached to it behind, and the dissection of a wet specimen has shown me its true position above the first branchial arch, which is at the top, and also *within* the Shoulder-girdle, altogether; moreover, that arch has its own *pseudo*-supra-scapular pieces, and does not need to borrow its piers from the arches that wall-in the pharynx. Any one familiar with the Ctenoid Fishes will know how curiously telescopic the arrangement of the *facio-faucial* arches is. In the Dory (*Zeus faber*) the corresponding first pharyngo-branchial articulates with the cross ray of the parasphenoid, close below the "foramen ovale," and directly below the front margin of the head of the "hyo-mandibular."

In a similar manner, higher up amongst the Classes, the "stapes" of the Bird lies *within* the enormous "os quadratum."

Here, in the *Lepidosiren*, the first branchial pier articulates further backwards, the upper part of its condyle being attached to the ex-occipital (e. o.); the middle with the basi-occipital cartilage (b. o.); and the lower part with the underlying parasphenoid (pa. s.)—the great, beam-shaped "basi-cranial splint." I may now throw aside these two bars (Plate II, fig. 1, p. b. 1 and p. b. 2), as not belonging to the Shoulder-girdle, and therefore having no right to further discussion here; besides, we have a thoroughly ichthyic suspensorium at hand, in its right place.

The upper splint of the shoulder-cincture is the post-temporal (Plate II, fig. 1, p. t.); it is a thin, sub-falcate, subcutaneous bone; it does not reach the epiotic region above, but is attached to it by a band of fibre; it is also similarly tied to the bone beneath, a considerable space intervening. This bone answers to Cuvier's "supra-scapula" in the Teleostei, and it is the exact counterpart of the subcutaneous peg which grows downwards from the hinder edge of the great post-temporal ganoid plate of *Clarias* (see Professor Huxley's 'Memoir on the Ganoids,' p. 30, fig. 20, s. s.), and of the inner or lower fork of the entirely subcutaneous post-temporal of ordinary Teleostei (see Plate II, figs. 6, 7, 8, p. t.).

At some distance below the post-temporal the supra-clavicle (fig. 1, s. cl.) is to be seen; it is much like the upper bone, but is straighter; and its position, relative to the cartilage within, and the clavicle below, is exactly what has been described in the Sturgeon (Plate I, figs. 6—8, s. cl.). Contrary to what is found in ordinary Fishes (Plate II, figs. 6, 7, 8, 9, and 12, s. cl.), it is somewhat *over*lapped by the large clavicle below it, but the overlapping of splint-bones is very variable (witness the interdigitation of the teeth of sutures); and as this bone is very thin and small, the bone below very large and thick, and as they both are in close contact with the outer face of the cartilage, which they invest, it is evident that this is merely a matter of overshadowing growth, having no more morphological value than the variations in the teeth of a suture. Using some degree of forecast in my comparisons, I may remark that if the outer lamina of the clavicle of *Cottus* (Plate II, fig. 12, cl., s. cl.) had grown forwards, and the inner plate had been arrested, then the supra-clavicle would have been *over*lapped by the clavicle, instead of the contrary, which actually obtains. Again, in the Herring (Plate II, fig. 6, cl., s. cl., p. cl.) the largely-developed posterior margin of the clavicle creeps within the post-clavicle as well as within the supra-clavicle. Below, in front of, and a little outside the little thin supra-clavicle, we see the large thick clavicle (fig. 1, cl.), which is sub-falcate in general form, scooped on its outer and convex on its inner face, and having its lower two fifths semicylindrical, the scooping being behind. This is a strong *green* bone, very typically ichthyic, and, like all the splint-bones of the Lepidosiren, wholly devoid of ganoid growth. Here we have the Teleostean Fish (excluding the aberrant Siluroids and Hippocampoids) closely approached by this most generalised type. Amongst the Ganoids it comes nearest to what obtains in *Lepidosteus* and *Amia*, for it has no "interclavicles," and the feebleness of the post-temporals reminds one of the Murænoids, which are actually devoid of these bones (see Plate II, fig. 9).

Not only did Professor Owen fail to find the post-temporal and supra-clavicles, but also the whole of the cartilaginous true Shoulder-girdle. As to this soft condition of the endo-skeletal part of the cincture, we have an interesting correspondence with those living Ganoids, *Calamoichthys*, *Amia*, and *Sturio;* and undoubtedly also with many of the forms that are buried in the primary rocks; and as we shall soon see, with the existing Hippocampoids. The coraco-scapular plate (fig. 1, sc. cr.) is scarcely half the size of the clavicle—a thoroughly ichthyic character; it is not unlike that bone in shape, being narrow above and in front, projecting backwards as a broad plate in the middle, and then narrowing to a blunt point below. It cleaves to the inner face of the clavicle and supra-clavicle, growing a little in front of the former, but not so high as the latter; there is a thin stratum of fibrous web between them. Behind, the upper moiety of the broad part is formed into a pedicellated cup—the true "glenoid cavity" (gl.); below the glenoid part there is a thin broader projection, which ends in a rather sharp angle, where the cartilage becomes suddenly cut away, in a crescentic manner, behind; the anterior margin is gently sinuous. A transverse line passing across the glenoid pedicel would be the base of the scapula; the rest belongs to the coracoid; this region has scarcely any projection forwards that can be called "præcoracoid." Now, whilst the Lepidosiren agrees with the Ganoid genera *Amia* and *Sturio* in having an unossified Shoulder-girdle, it also equally agrees with the Placoids in having a well-developed epicoracoid belt (figs. 1, 2, 3, e. cr.). Professor Owen, speaking of the Sturgeon, expressly says ('Lectures,' vol. ii, p. 133) that "the scapulo-coracoid arch is completed below, as in Lepidosiren, by ligamentous union, not, as in Sharks, by cartilaginous confluence." True, indeed, as to the Sturgeon, but erroneous as to the Lepidosiren. Originally, the epicoracoid mass must have been double; and perhaps in a very early stage each moiety was continuous with the coracoid proper, but a wide transverse cleft is soon formed, such as is seen between the scapula and the coracoid in *Cottus* (Plate II, fig. 12, sc. p. cr.), and in other Fishes with large brachials, *e.g. Anarrhichas*, *Trigla*, &c. Above, this spindle-shaped, bi-polar bar is cupped in its broad middle part (fig. 2); below (fig. 3), it is subcarinate; each ramus ends in a blunt point, and is sheathed below and behind, by the scooped lower end of the clavicle. Here we stand, as it were, with one foot amongst the Plagiostomes and the other planted within the Teleostean boundaries; and the epicoracoids are cut off from the coracoids, that Nature may be ready to throw them aside when she comes to the typical Fishes. The Amphibia, which are also Dipnoi, will require these plates again, enlarged and expanded, to form in them a double-breasted vestment of cartilage; in them these cartilages will be found to be continuous with the main part, a character not to be lost again until the observer has risen above the Monotremes; the parts themselves, however, are to be found even amongst the Bats. Notwithstanding the Placoid character of the epicoracoids, there is nothing like the Microscopic bony pavement of the Sharks and Rays, and the livid colour of the cartilage is in strong contrast with the sea-green colour of the bones outlying it. In all the long rods of cartilage the Lepidosiren agrees with the Sturgeons and Teleostei in having the ossification of the *ectosteal* kind (fig. 1, p. b. 1), but, as in the Sturgeon and some of the Teleostei (*e.g. Gobius, Cyclopterus,*) it is very feeble and arrested.

The rays of cartilage (wholly unossified) in the long, fringed ("crossopterygian") fin are rather compressed from side to side (fig. 1, c. 2), and are about three times longer than they are broad. The convex proximal end of the first, or humerus (h.), articulates with the glenoid cup (gl.); then comes the radio-ulnar (r. u.); first carpal (c. 1); second carpal (c. 2); and phalanges (ph.); the smallest of those shown in the figure are the 20th and 21st; but these were not the terminal segments.

Pisces teleostei (*A. Siluroidei*).

Example 1.—*Callichthys littoralis,* Günth. (the Round-headed Hassar).

My figures (Plate I, figs. 9—13) of this exquisite fish are from a specimen five inches in length, and are magnified two diameters. As this fish lies in the very channel which leads from the Ganoids to the Teleosteans, and as the outer and inner bones of the shoulder-girdle cannot be understood irrelatively, I shall make little apology for describing parts that lie beyond my border. If *Clarias* be valuable as throwing light upon the fishes of the Old Red Sandstone, a still more important link is found in *Callichthys,* a Siluroid in which the ganoid plates are much more abundant and perfect. All the bones that can be seen in this fish immediately beneath the extremely thin *cuticle* are dermal; but the anterior and under parts of the face are covered with thick skin, beneath which are to be found both subcutaneous dermals and true endo-skeletals. All the bones that appear with their dense enamel-like coat at the surface have unpolished parts hidden below, but I can find no separation into distinct ganoid and subcutaneous bones in any region of the exo-skeleton. Such a separation does occur in the Lophobranchii, as I shall soon show. In Plate I, fig. 9, there are no subcutaneous bones shown; and, indeed, the præ-maxillaries, maxillaries, dentaries, angulars, preoperculars (squamosals), inter-operculars (the sub-operculars are wanting), branchiostegals, and the so-called uro-hyal—all these are subcutaneous, and the skin over them is very thick. The endo-skeletal skull-elements, like those of the rest of the skeleton, are converted into strong fibrous bone, and it is impossible that any of them should be seen from without, seeing they are all covered with the dense ganoid helmet. This splendid armour must be removed before the præ- and post-frontals, the ethmoids, the pterotics, the epiotics, and the supra-occipital can be displayed on the upper part of the head; the Shoulder-girdle, also, is almost entirely hidden within the huge enamelled shoulder-plates; the glenoid bosses just peeping out between the joints of the harness (see fig. 9, gl.).

On the head there may be seen the *quasi*-ethmoid or meso-nasal (Plate I, fig. 9, m. n.); two nasals (n.); two frontals (f.), separated by a large fontanelle (fo.) for the most part, but united by suture at each end; two lachrymals or præ-orbitals (l.); two suborbitals (su. o.); two post-orbitals (pt. o.); two dermo-post-frontals (d. pt. f.); one large parietal (p.); two large dermo-supra-occipitals (d. s. o.); two dermo-epiotics (d. ep); two large supra-temporals (s. t.); and two operculars (op.). Each frontal is pierced near its middle, and each dermo-post-frontal near its lower margin, for a mucous duct. Each supra-temporal is pierced in four places for ducts, and slit through near the top to form the spiracular chink. Behind these plates the whole body is enveloped in a right and left series of supero-lateral plates, and the same of infero-lateral plates; the first cincture is further subdivided over the Shoulder-girdle, and the last cincture over the base of the tail-fin. The supero-lateral bones are directed downwards and forwards, the infero-lateral downwards and backwards (Plate I, fig. 9); they end in a blunted triangle, and the lower part of the upper plates overlaps the upper part of the lower. The upper and lower plates are very much alike; they are equally arcuate, equally convex (at their junction they form a shallow furrow), and of equal width and length; but there is this difference, namely that near their base the upper ones are pierced in front and notched behind for mucous glands. If this portion were cut off by a suture in each upper plate we should have the "lateral-line" mucous bones of typical Teleostei; this does take place in the first cincture (fig. 9, p. t.); this tuberous, doubly notched bone being the supra-scapula of authors, but entitled "post-temporal" in this Memoir. There are twenty-five of these cinctures, which are not perfect either above or below, as they leave a space both on the spinal and the abdominal line. Above, the broad-topped supero-laterals of the first body-belt meet by a long suture, like the symmetrical dermo-supra-occipitals (d. so. s. l. 1); the second supero-lateral, which has undergone no segmentation below, scarcely meets its fellow of the opposite side, but, retiring from it behind, leaves an interspace which is filled up by a highly polished, crescentic, dermo-spinal (fig. 9, d. sp. 1). Next behind this comes the symmetrical, but coalesced, first ray of the first dorsal fin (d. sp. 2); it is a stout, sharp spine. Then follow seven feebler, symmetrical, jointed rays, and these are succeeded by ten polygonal ganoid plates (fig. 10, d. sp., shows five of these), which begin to be ridged and spinous behind, the last but two having a small prickle, and the last a strong spine; these have the single coalesced spine of the "second dorsal" coming next; then the dermo-spinals are absent over two cinctures, where the little fin-flap is attached; behind the "second dorsal" there are three or four symmetrical bones, flat at first, but passing gradually into the strongly spinous, symmetrical rays that form the base of the upper lobe of the "caudal fin."

Below, the small subcutaneous "basi-branchiostegal"—the so-called "uro-hyal"—is the only azygous bone until we come to the space between the "anal fin" and the lower lobe of the "caudal fin;" in that interspace there are two very convex ganoid plates, followed by the symmetrical rays of the lower caudal lobe. There is no true spinal derm-bone in the head; the first body-belt has none (s. l. 1); the two supra-occipital derm-bones, the single parietal, the symmetrical frontals, the single dermo-ethmoid,[1]—all these are serial homologues, whether azygous or symmetrical, of the upper three fourths of the supero-lateral plates, and not of the dermo-spinals (Plate I, fig. 10, d. sp.). The segment which is cut off from the first "supero-lateral," and which is continuous in all the rest, save the last, or 25th, reappears (homologically) in the head, as the supra-temporal (s. t.); then this series becomes double, and we have the "dermal post-frontal" (d. pt. f.), post-orbital (pt. o.), sub-orbital (su. o.), lacrymal (l.), and nasal (n.). The first infero-lateral plate is subdivided on the left side into two, and on the right side into three plates; these are in relation with the Shoulder-girdle, and may be called supra-clavicle (s. cl.), clavicle (cl.), and inter-clavicle (i. cl.): I shall describe these anon. But this subdivision becomes greater in the head; the opercular (op.) repeats the supra-clavicle, and the sub-opercular (not present in this Fish) the clavicle: in this,—the "hyoid" dermal cincture,—we have, *below*, the branchiostegals, and the so-called uro-hyal as a lower spine-bone. In this Fish, as in the Cyprinoids, there are only three branchiostegals; but in "the clupeoid *Elops* there are more than thirty" (Owen, 'Lectures,' vol. ii, p. 115). This lower part is thus seen to correspond with the inter-clavicular region. The opercular has the squamosal (pre-opercular) as its homotype, and the sub-opercular is preceded by the inter-opercular (see Huxley and Hawkins's 'Atlas,' plate 5, fig. 2, where the letters P. op. are by mistake put to the quadratum of *Lepidosteus;* the pre-opercular is the large sickle-shaped bone above I. op.). The lower hyoid and the inter-clavicular regions have their homotypic scales in the jugulars (not present in *Callichthys*) and in the splints of the mandible: the splints (subcutaneous bones) in front of and above the mouth must be left until I have time to work out the whole skull; the premaxillaries, maxillaries, jugals, quadrato-jugals, pterygo-palatine splints, and parasphenoid, all come under this category, and must all be studied in relation to the bony armour generally. Nevertheless, what has just been written is necessary for right views upon the parts that enclose, and often become isomorphic of, the true Shoulder-girdle. I must now return to these Shoulder-plates, but the post-temporal need not be further described. The supra-clavicle (fig. 9, s. cl.) is an oblong plate, turned obliquely downwards and forwards, and overlapping the equally oblique upper margin of the clavicle (cl.); it is not separate from the clavicle on the left side, but the subcutaneous peg which articulates with the post-temporal is seen in figs. 11 and 12, notwithstanding its connate condition in that left plate. It has a large ganoid surface; the subcutaneous part being the process which passes within the post-temporal; the antero-superior margin, which is overlain by the supra-temporal; and the antero-inferior margin, which passes within the operculum (fig. 9, s. cl., p. t., s. t., op.).

The clavicle (figs. 9, 11, 12, and 13, cl.) of *Callichthys* would not, at first sight, be recognised as such; this arises from the continuity of its essential part with a large ganoid plate: this plate is distinct in the Lophobranchii; and thus the typical clavicle is at once understood. The outer aspect of this bone (fig. 9) is that of a triangle, with the anterior angle produced downwards and inwards, in front of the inter-clavicle (i. cl.): but there is a large subcutaneous plate hidden in this aspect, which forms the hinder wall of the gill-opening. The concave anterior aspect of this

[1] This bone is enough to deceive the shrewdest anatomist; it is truly a *meso-nasal:* Professor Owen's "nasal" (see 'Lect.,' vol. ii, p. 100) is the true "ethmoid," and lies beneath it: it is lettered *eth.* all through Mr. Huxley's Memoir.

inner lamina is seen in fig. 11; its hinder convex aspect is seen in fig. 12; here it is seen to resemble, very accurately, a semi-lunar aortal valve: part of this half-moon-shaped plate belongs to the supra-clavicle. The extension downwards of the clavicle enables each bone to meet its fellow at the mid-line; but the suture is of short extent (fig. 13, cl.) Behind this descending part there is a large semi-elliptic notch, which is converted into a foramen by the inter-clavicle: through this space the "glenoid" bosses (gl.) of the coraco-scapular plate pass.

The inter-clavicle (i. cl.) forms a large base to the clavicular triangle (fig. 9); it is articulated to the clavicle by a finely toothed suture, which is broken at the great passage for the pectoral fin. The lower margin of the ganoid plate of the clavicle is convex,—the corresponding upper edge of the inter-clavicle concave: there is a shallow fossa along this line, in which the pectoral fin lies when at rest. Nearly the whole of the inter-clavicle is ganoid (see fig. 13, i. cl.); the subcutaneous part is triangular, and with the corresponding part of the opposite side forms a lozenge, the halves of which are united by a strongly toothed suture: more than two thirds of the inner margins of these bones are free, and diverge more and more behind. Here, in this Siluroid, we see very much of the Sturgeon, and a great unlikeness to the typical Teleostean; but the clavicles do meet below, as in the latter.

There is still another plate which has relation to the Shoulder-girdle; this is the "second infero-lateral" or "post-clavicle" (fig. 9, p. cl.), the subcutaneous part of which is represented by one, two, or three bones in the Teleostei proper. (See Plate I, fig. 14; and Pl. II, figs. 6 and 8, p. cl.)

If only the inner part of cl. and p. cl. in fig. 9 were developed, then the latter would at its upper part pass in behind the former at an angle a few degrees below a right angle. (Compare Plate I, figs. 9 and 14; and Plate II, figs. 6, 7, 8, and 12, cl. p. cl.)

Shoulder-plates of Siluroids.

A. Callichthys: left side; inner view. B, C. Clarias: left side; B inner, and C hinder view.

Fig. 2 A.
(Magn. 4 diam.)

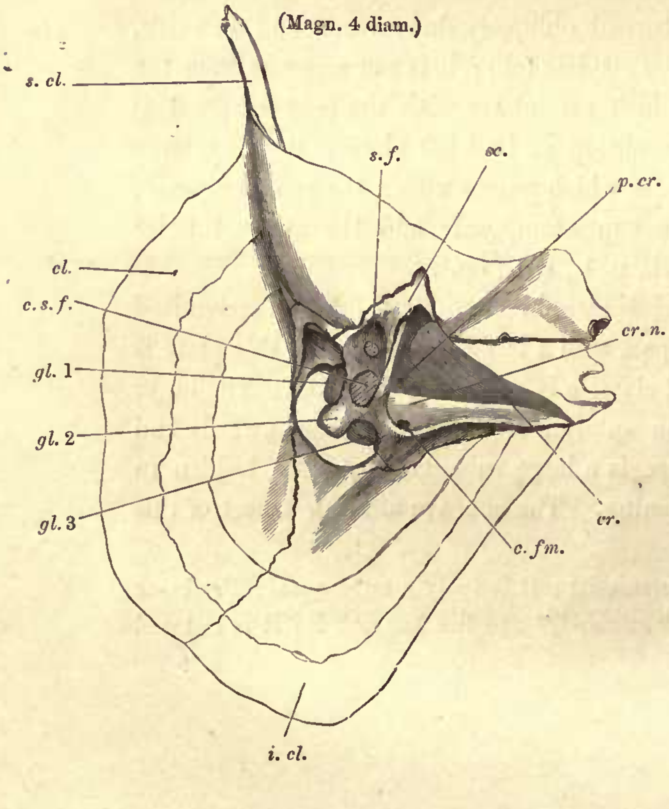


Fig. 2 B.
(Nat. size.)

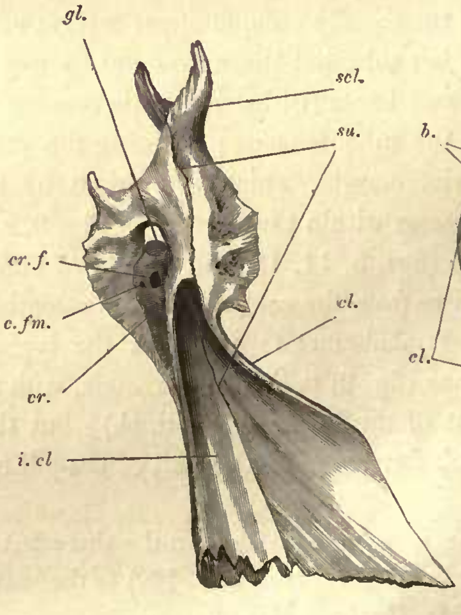
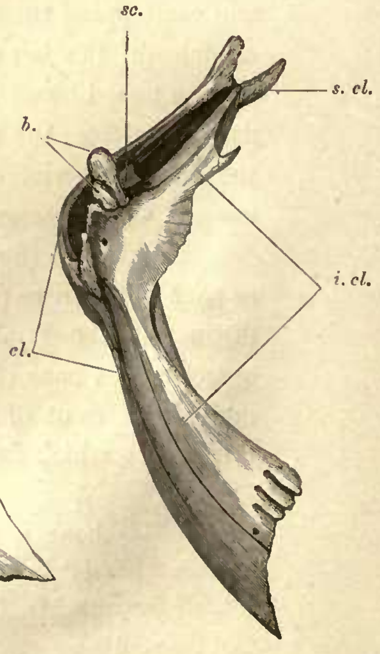


Fig. 2 C.
(Nat. size.)



The true essential Shoulder-girdle moiety is very small relatively to the great dermal plates that outlie it (see fig. 12, sc. p. cr., cr.); but it is highly ossified, and partly anchylosed to the dermal plates: moreover, its own three elements are to a considerable extent coalesced. The early condition of the Shoulder-girdle of this Siluroid is persistent in the Trout and Herring (see Plate II, figs. 4, 5, 7, 8); and in them the relations of the scapula (sc.), pre-coracoid (p. cr.), and coracoid (cr.) are clearly shown.

The three glenoid bosses (Pl. I, fig. 11, gl. 1, 2, and 3) are arranged in a curved manner; the upper looking forwards and outwards, the middle backwards, and the lowest backwards and outwards: they articulate with the large, uppermost dentate ray (or spine) of the pectoral fin. These oblong, convex condyles belong principally to the scapula (sc.), and they are partly articulated with the three brachials, which are slightly displaced by the *dermal* ray, whilst the ray itself articulates both with the scapula and the clavicle. There is a large "coraco-scapular fenestra" (see fig. 12), and in front of it a smaller "scapular fenestra;" so that here, as in the Skate (*Raia*), there is a scapular, a meso-scapular, and a præ-scapular bar. The præ-scapula sends backwards a bony style, inside which the pointed præ-coracoid passes; these two are strongly tied together, to form the bony bar seen at p. cr. in fig. 12. There is a large "coracoid foramen" (see fig. 2 A, c. fm.) at the root of the præ-coracoid (see fig. 12); it lies in the angle of the "coracoid notch" (cr. n.); the main coracoid (cr.) is deeply grooved within, it is almost anchylosed to the inter-clavicle, and ends in a point within and behind its last sutural tooth. It must be remarked that the scapula is very low and broad, so that the glenoid bosses lie obliquely behind its upper part: their high position arises from their relation to the "pectoral dermal spine." Professor Huxley, in his invaluable 'Memoir on the Ganoids,' pp. 34, 35, speaks of the inter-clavicle as "the so-called radius" (p. 35, fig. 21, *d*); but it has nothing to do with Professor Owen's "radius," which is in reality the coracoid. (See Plate I, fig. 14, cl. cr., for an easy explanation of the manner in which this mistake occurred; for the coracoid of the Siluroids, as we have just seen, is anchylosed to the inside of the inter-clavicle, but in fig. 14, which shows these plates in the Dory, the coracoid is exposed, having no inter-clavicle outside it.)

The Woodcut (fig. 2 A) will give a clearer idea of the structure and relations of the Shoulder girdle and its splints in *Callichthys* than the figures in Plate I. This sketch represents the parts as magnified four diameters, and the dermal bones are partly left in outline. The scapula (sc.) is seen to rise but little above the glenoid bosses (gl., 1, 2, 3), and the manner in which the scapula sends a style across to that of the pre-coracoid (p. cr.) is clearly shown; so also is the coraco-scapular fenestra (c. s. f.), the scapular fenestra (s. f.), the coracoid foramen (c. fm.), and the deeply grooved coracoid itself, strongly attached to the inter-clavicle (i. cl.), which hides it on the outside. Above the scapula, part of the deeply scooped facet for the pectoral spine is seen in the angular space of the clavicle (cl.).

Example 2.—*Clarias capensis.*[1]

For illustration of the Shoulder-girdle in this Siluroid I may refer, not only to the Woodcuts (figs. 2 B, 2 C), but also to Huxley and Hawkins's 'Atlas,' plate 11, figs. 11*a*, 11*b*, and to the

[1] From a dissection of one of Professor Huxley's specimens from Congo, mentioned in his 'Memoir on the Ganoids,' p. 33.

'Memoir on the Ganoids,' figs. 20, 21. The post-temporal plate (ibid., p. 30, fig. 20, *S. S.*) has a large ganoid portion flush with the top of the flat skull, and articulated by suture with the supra-temporal (*S. T.*) and the parietal (*Pa.—Ep.*). Behind, it sends downwards a strong peg of subcutaneous bone, which articulates with the anterior or supra-clavicular fork of the clavicle.

There are only two other dermal bones in relation with the true Shoulder-girdle; for the supra-clavicle ('Atlas,' plate 11, fig. 11*a*) is not separate from the clavicle (*a*), but the inter-clavicle (*b*) is nearly as large as the clavicle. These bones are very strong and fibrous, and only part of the clavicle—namely, the middle third below the pectoral fin, and the prickle in front of it —has any "ganoid" thickening. The junction of the dermal moieties below is very strong indeed (see 'Atlas,' plate 11, fig. 11*b*, and 'Mem. on Gan.,' p. 35, fig. 21), the sutural teeth joining the inter-clavicle being especially large. As the true Shoulder-girdle is at first sight almost indistinguishable in the adult, I shall describe its outlines first. The Woodcut (fig. 2 B) shows these parts, full size, the view being the inside of the left moiety; and it is seen that the inter-clavicle (i. cl.) mounts up nearly to the division of the clavicle into a supra-clavicular and a clavicular fork (s. cl., cl.). Here is seen at once a notable divergence from the structure of *Callichthys;* and it may be remarked that a Memoir on the Osteology of the Siluroids would be a great treasure, for these Fishes bridge over the space between the Ganoidei and the Teleostei; for if my first two instances, taken at haphazard, differ so intensely, it follows, of course, that this great group would show a most instructive diversity. The clavicle is extremely thick where it is deeply notched for the pectoral fin, having inside this part a deep crescentic condyloid excavation for the serrated dermal ray (Woodcut, fig. 2 C, cl.). Its middle third is somewhat enamelled below the hinge. This part is shown to be divided by a groove from the posterior third, in the hind view (fig. 2 C). It is well bent on itself, is concave within, and, gradually widening below, runs into a large angular plate, which meets its fellow of the opposite side, and is interlocked by rather small teeth. The inter-clavicle (i. cl.) is two-thirds the size of the clavicle, and has much in common with it. On its hinder margin (fig. 2 B, i. cl.) it sends upwards a prickle, then expands in an elegantly crescentic manner, narrowing again half an inch below the fin, where it is considerably overlapped by the clavicle (fig. 2 C). Both these bones send inwards an "aponeurotic" lamina; and these laminæ, joining together within and behind the hinge, form a bridge over a deep rounded valley (fig. 2 B). There is a lesser valley behind the lamina of the inter-clavicle and its posterior crescentic expansion, and in this valley lies the coracoid (cr.). Above the hinge the two bones form another valley, deep and ditch-like. This contains the upper part of the scapula (fig. 2 C, cl. sc.). The true Shoulder-girdle can only be seen by using the pocket-lens; then its different texture comes out; but it is entirely anchylosed to the great splints. In fig. 2 C, the scapula (sc.) is seen bridging over the bottom part of the deep upper valley; below this it is lost in the glenoid masses formed by it and by the clavicle and inter-clavicle. A large bristle may be passed beneath the scapular bridge (fig. 2 C, sc.). The coracoid (cr.) may be seen in the postero-inferior valley, the bottom of which it fills, and in it may be seen the coracoid notch converted into a fenestra by the inter-clavicle (cr. f., i. cl.); and directly behind this another landmark, the coracoid foramen (fig. 2 B, c. fm.), can be clearly seen: so that, although the two great splints are persistently separate, yet the elements of the essential Shoulder-girdle are not only entirely fused together, but also with the enclosing splints. They are very minute relatively, more so than in *Polypterus*, *Amia*, or *Callichthys*. There are only two brachials (fig. 2 C, b.); they are flat, but thick, and the upper is twice as large as the lower; they are articulated to a ridge of the inter-clavicle; for the large complex condyloid facets of the great, serrated dermal spine of the pectoral fin takes up the room due to these true limb-rays, and acquires, moreover, a large amount of articular surface on the clavicle and inter-clavicle besides. The remarkable trumpet-shaped cavities behind and below *S. S.* and *S. O.*, shown in Professor Huxley's figure ('Mem. on Gan.,' p. 30, fig. 20), belong to the "atlas" and "axis" vertebræ, and they are strongly attached to the post-temporals and clavicles at their point of junction; they lodge the lateral cornua of the three-lobed air-bladder. These cavities are very imperfect below; but this deficiency is largely supplemented by a transverse splint on each side, attached, below, to the anterior edge of the great semi-cylinder of the "atlas." There is a smaller splint in each cavity, and two still smaller splints eke out the mouth of each of these trumpets. The large obliquely transverse splints (they are somewhat turned backwards) meet within a line and a half below the centrum of the "atlas;" between and behind the splints, this and the next centrum are deeply grooved.

I mention this structure to exclude the attached splints from the clavicular category, although I shall have to describe a splint similar to the largest which is really correlated to that system in *Ostracion;* also to show the relation of this structure to what is seen on one hand in the Cyprinoids, and on the other in certain Gadoids, *e.g.* in the Hake (*Merlucius vulgaris,* Cuv.).

Nor, in considering the multifarious affinities of this type, must the elegant gill-arch flaps, with their cartilaginous rays, be forgotten; a structure repeated from the Plagiostomes: nor must we omit to mention the remarkable dendritic gill-tufts in this Fish which made Geoffroy give it the title *Heterobranchus* (*Clarias,* Gronovius). (See Cuvier's 'Animal Kingdom,' Griffith and Hamilton Smith's Transl., p. 408.)

The figure given by Professor Huxley (op. cit., p. 34, fig. 20, from Cuv. and Valenc. 'Hist. Nat. des Poiss.') of *Arius rita* shows the heart-shaped *ganoid* portion of the "post-temporal," and directly below it an enormous oblong plate, which is the outer part of the clavicle. It is possible that if this were examined carefully, an inter-clavicular portion might be seen even from the surface. On the next page (fig. 21) there is an outline sketch of the hyoid and thoracic plates of *Loricaria,* seen from below. In this figure, *c* is the clavicle; *d* the inter-clavicle. In the Hunterian Museum (see 'Osteol. Catal.,' vol. i, p. 23, No. 70) there is a very valuable skeleton of a *Silurus,* in which the inter-clavicles are very strong; and where the post-temporals and clavicles have a ganoid portion, the former is bifurcate above, thus showing an approach to the ordinary Teleostei.

Fossil Siluroids.

In the Memoir just quoted, Professor Huxley (pp. 29—37) gives his reasons for placing *Coccosteus* "in a place near, if not among, the Siluroidei;" fig. 19, p. 30, shows an outline plan of the skull of this extinct Fish. Here *S, s,* is the post-temporal plate; and *b*, the next supero-lateral plate—its serial homologue. The clavicle is lettered *c*, and it seems to have no supra-clavicular bone segmented from it. The large bones below are best seen in fig. 21, p. 35; where *c'* is the huge inter-clavicle; and it will be seen that in this bone we have the counterpart of the lowest bone in the dermal Shoulder-girdle of the Sturgeon (Plate I, figs. 6—8). In the Siluroids the clavicles meet in front of the inter-clavicles; not so in *Sturio* and *Coccosteus*. The bones lettered *d′* may either belong to the post-clavicular cincture, or they may answer, in their subcutaneous portion, to the second pair of inter-clavicular bones soon to be described in the Lophobranchii. The key-stone pieces *b*, *e*, are the exact counterparts of the first two "abdominal-line" plates of the Lophobranchii,—*e. g. Hippocampus, Syngnathus, Phyllopteryx*. Counterparts of these bones are also familiarly known in the Clupeoids (see Yarrell's 'British Fishes,' 1836, vol. ii, p. 107; where a figure of one of these, from the Pilchard, is given). As it is necessary to call in the Sturgeon and Sea-Horse to explain the *Coccosteus*, it may, perhaps, be well to leave its classification in a provisional condition for the present.

B. Lophobranchii.

The Siluroids once passed, a great change is seen even in those Fishes that still retain the ganoid armour; for the inner portion of the dermal system of bones is now differentiated from the outer, and is correlated more perfectly to the contiguous parts of the endo-skeleton.

Shoulder-plates of Hippocampoids.

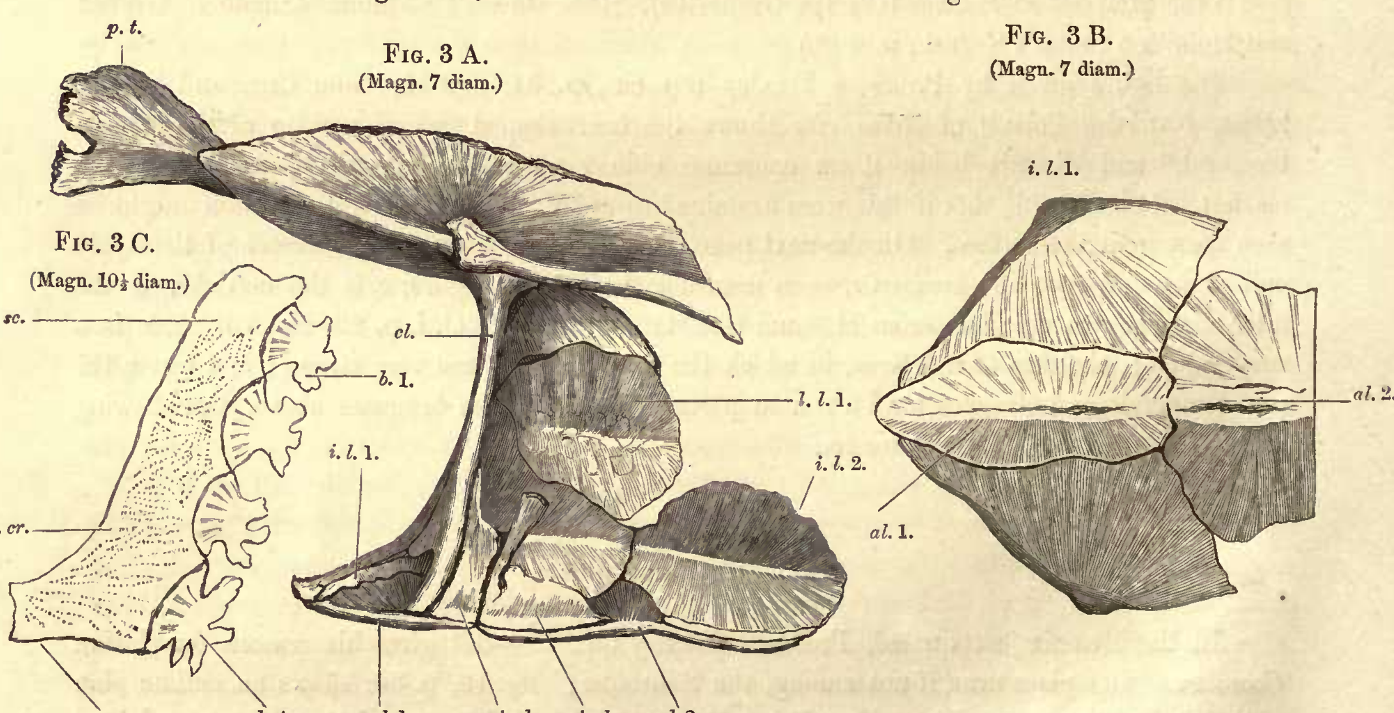
Syngnathus Acus, Linn.

A and C. Right side, inner view. B. Lower view of right and left side.

Fig. 3 A. (Magn. 7 diam.)

Fig. 3 B. (Magn. 7 diam.)

Fig. 3 C. (Magn. 10½ diam.)



The Hippocampoids may be described first, and the great Pipe-Fish (*Syngnathus acus*) may be taken as the type. Here the large, leaf-like, ganoid scales can be entirely dissected away from the clavicular cincture: this latter system of bones will be found to be strong, although fibrous, and very different from what we have seen in the Fishes already described, and also from the typical Teleostei. In *S. acus* there are two dorsal-line plates behind the occiput, and then the back is concave, being finished above by the supero-lateral series. There is then a lateral series; the first of these is shown in the Woodcut, fig. 3 A, l. l. 1: then an infero-lateral, figs. 3 A and 3 B, i. l. 1, i. l. 2; whilst the trunk is walled-in below by the abdominal-line series, a. l. 1, a. l. 2. These plates vary as to the number of rows, even in the British species of *Syngnathus* (see Yarrell's 'British Fishes,' vol. ii, p. 325—341.)

There is a post-temporal scale (fig. 3 A, p. t.) below the first post-occipital; but there is no distinct supra-clavicle; hence the large size of the clavicle (fig. 3 A, cl.) This bone is T-shaped, the descending crus being almost vertical; it leans a little forwards in its descent, and there is a large backward development of the bone, strengthened by an internal beam, below. The lower third of the anterior plate is similarly fortified, and these two bars swell into a rough boss at their junction. Above, the bone is smooth, but thick; and it is full of the elegant radiate markings common to this and the ordinary scales. The bone all along the top is composed of two distinct plates; the outer being the inner half of the skin ossified and answering to the ganoid plates generally, and the inner lamina being a layer of ossified subcutaneous fibres. The post-temporal, (fig. 3 A, p. t.), is a triangular ganoid plate, notched in front; the supra-clavicle has no separate existence; and here, as in many other Teleostei, the upper parts of the dermal Shoulder-bones are, to some degree, ganoid as well as subcutaneous; and thus the space between the Ganoids and Siluroids, on one hand, and the typical Teleostei, on the other, is partly bridged over. The main partof the descending crus of the clavicle appears within, as a rounded rod, which bifurcates below; the outer fork being the shortest, and having the first infero-lateral scale strongly clamping it in front (see fig. 3 A, cl., i. l. 1); whilst the longer, inner spur rests upon the submesial part of the first abdominal-line plate (fig. 3 A, cl., a. l. 1). In some Fishes (*e. g.* Cottoidei) there is a large development of the clavicle internally; the strong aponeurotic band which lies directly outside the "peritoneum" being ossified, and lying *inside* the true Shoulder-girdle (see Plate II, 7 *n*, fig. 12, cl. cr.).

There is no such plate growing from the clavicle within and below in *Syngnathus;* but this is replaced by two separate bones not seen, as a rule, in the Teleostei generally. The descending rod of the clavicle, however, has an outer wing to it, the greater part of which is seen in fig. 3 A, cl., overlying and partly protected by the first lateral plate (l. l. 1): this infero-posterior wing is, in some degree, ganoid; there is evidently a scale connate with it, as in the upper part of the clavicle.

Referring again to the clavicle of *Cottus bubalis* (Plate II, fig. 12, cl.), it will be seen that the clavicular plate which passes within the coracoid (cr.) has two additional ossicles (a. i. cl., p. i. cl.): these two bones are represented in *Syngnathus* by much larger bones, which take the place of the whole inner plate of *Cottus* (Woodcut, fig. 3 A, a. i. cl., p. i. cl.). Both these bones are *behind* the inner fork of the base of the clavicle, and, therefore, neither of them can represent the "ischio-pubis," which, in the *Cottus*, as in other Thoracic Fishes, passes *within* the lower part of the clavicle, and is tilted up in front, so as to leave some space between the pubic extremity and the base of the clavicle, where it rests on the skin, below. But the *Syngnathus* has no pelvic members; and if it had a "pelvis" without the fins, yet, as the posterior arch is always morphologically inferior to the anterior or scapular, it could not be bony in this instance, seeing that the Shoulder-girdle itself is entirely unossified.

Moreover, these "interclavicular" bones are entirely fibrous (see fig. 3 A, a. i. cl., p. i. cl.);

rest completely on the first abdominal-line scale; and are wholly behind the clavicle. The presence of the first of these splints would have been no difficulty; the presence of a second need be none, when "Nature herself teaches us" how she has subdivided the clavicle in *Cottus*. The foremost bone (a. i. cl.) is like a hatchet, set on end; the pointed haft running up behind the descending crus of the clavicle. The next bone (p. i. cl.), or "posterior inter-clavicle," has a blade below, and a haft, set on obliquely, above: this haft is flat, and broad at the top; it is turned somewhat outwards and backwards. The meaning of this broad top will be seen when we come to *Ostracion*; its double lamina and open end caused me trouble at first; but high magnifying powers show nothing more than fine fibrous tissue in the interspace between the outer and inner plates; so that it is a purely aponeurotic bone.

It is well that there is always a good landmark in the main Shoulder-splint, namely, the clavicle, for, whilst one of the typical upper splints is wanting here, there is the apparent confusion of two atypical bones below.[1]

The true Shoulder-girdle of *Syngnathus* is of extreme interest, as it is persistently soft, and has undergone no segmentation.

This curious thin flap of hyaline cartilage (see Woodcut, fig. 3 C, where the right moiety is shown from the inside, magnified 10½ diameters) increases in width in passing from the scapular region (sc.) to the coracoid (cr.). The scapula is somewhat emarginate above, and the coracoid below; and the posterior margin is crenate, and interdigitates with the brachial rays (b. 1—4). The outline of the entire cartilage reminds one of those Caterpillars that lift their head whilst crawling over the plant on which they feed. The gently sinuous, scooped front margin of the cartilage can scarcely be said to be "notched," and there is no "fenestral" rudiment of a cleft. The small "feet" which insinuate themselves between the massive, bony brachials have a clean margin, towards which, as towards the whole circumference, the cartilage cells become flat and parallel with each other.

The brachials (fig. 3 C, b. 1—4) are deeply notched both above and below, the hinder parts being a partly separated second series. The anterior brachial moieties are almost semicircular, and lie in the moon-shaped "glenoid" spaces of the coraco-scapular cartilage. They have a core of cartilage in their inner part; but their outer halves, or post-brachial moieties, are intensely ossified, and converted by periosteal growths into extraordinary stag's-horn appendages. On the outer side, some of these become upturned hooks of great length, and flattened like anchor-flukes; so that the rays of the fin-root are in the strongest histological contrast to the coraco-scapular foundation of the fin.

In the still more bizarre forms seen in the genus *Hippocampus* the abdominal-line series are much more carinate than in *Syngnathus*; and the whole of its structure would well repay the morphologist who would work it well out. But the most unlooked-for modification of the ichthyic vertebrate is to be seen in the genus *Phyllopteryx*, Kaup. I refer the reader to the exquisite plates (by Mr. G. H. Ford) in the 'Transactions of the Zoological Society' for 1865 (Part I, plates 14 and 15, p. 327). A knowledge of the structure of the common kinds of *Syngnathus* makes this strangest of types quite intelligible.

[1] The relation of these Fishes to the generalised Ganoids is well shown by their possession of "malars" or "jugals," and still more by the presence of the "jugulars," so rare in the Teleostei, namely in *Elops* and *Megalops* (Cuv., 'Règ. Anim.'). These are well developed in *Syngnathus* and *Hippocampus*; although I am not aware that any other Ichthyotomist has observed this fact.

Ordo "Plectognathi."

Example 1.—*Ostracion auritus*, Shaw.

My specimen of this Trunk-fish measures two and a half inches in length, and is therefore about half grown. I have been long familiar with the complete differentiation of the ossifications of the "cutis vera" from those of the looser fibrous layers within in this genus. The Woodcut (figs. 4 A, 4 B), shows the Shoulder-girdle and its extensive system of subcutaneous splints, magnified three diameters. In fig. 4 A these latter bones are shown from the right side, the view being from within. Fig. 4 B shows the Shoulder-girdle moiety, with the large splint-bone that underprops it. Professor Owen ('Osteol. Catal. Hunt. Mus.,' vol. i, p. 81, No. 362) aptly compares the bones of *Orthagoriscus mola* (the Sun-fish) to decayed wood. Those of the Trunk-fishes have this same touchwood consistence, totally unlike those of the Balistidæ, which have them much more dense and ivory-like. The post-temporal and supra-clavicle (fig. 4 A, p. t., s. cl.) together form a thin triangular plate, convex on the outside, where it adheres to the hexagonal plates, and concave within. The post-temporal has a thick, incurved edge above; and this part thickens still more where the bony fibres spread over the delicate cap-like "epiotic." The supra-clavicle (s. cl.) has a small spur in front, and ends in a strong peg below; in front it is attached to the outer occipital region; its hinder margin is lunate, and below it is clamped by a strong, rod-like splint, which passes across to the "basis cranii," just where the "parasphenoid" interdigitates with the "basi-occipital." I shall provisionally call this bone the "præ-clavicle" (fig. 4 A, pr. cl.); it curls up behind the supra-clavicle externally, and separates it from the broad shell-like top of the clavicle. I have described a similar splint-bone in *Clarias* (p. 29), which runs across from the junction of the clavicle with the supra-temporal to the under surface of the "atlantal" centrum. These bones may be true homologues; they are at least the same serially. Between this bar and the broad top of the clavicle, in front, there is a rod of cartilage (p.), which seems to answer to the so-called scapula of the *Lepidosiren*, and is probably an autogenous "pharyngo-branchial." Between the supra-clavicle and the clavicle there is, behind, the pedate upper end of the upper post-clavicle (u. p. cl.), so that there are here four bones set on to each other by a peculiar kind of carpentry. The clavicle (cl.) is the largest bone of the seven that are built above, below, and around the true Shoulder-girdle; its anterior concave surface is of great breadth —greatest where it appears narrow in the side view, as in the figure. This back wall to the branchial cavity is transverse to the axis of the body. The high triangle, with its incurved posterior margin, which runs down to the abdominal line, grows out of the middle of the anterior plate, so that the whole bone is three-winged. Above, the clavicle forms an elegant thin shell below the præ-clavicular bar; this bone is widest in the middle, where it runs across the thoracic cavity to underprop the obliquely oval doorway through which the pectoral fin passes. The external lamina becomes very narrow, but reaches the base of the bone; the inner wing stops midway on the edge of the vertically longitudinal plate; the base of the latter is thin, but is composed of two laminæ. The upper post-clavicle (u. p. cl.) is a considerable bar of bone, dilated in front (above), where it wedges itself in between the præ-clavicle and clavicle, and

SHOULDER-PLATES OF PLECTOGNATHI.

FIG. 4. A, B. OSTRACION. C, D. TETRODON.

FIG. 4 A. Right shoulder-splints; inner view.

(Magn. 3 diam.)

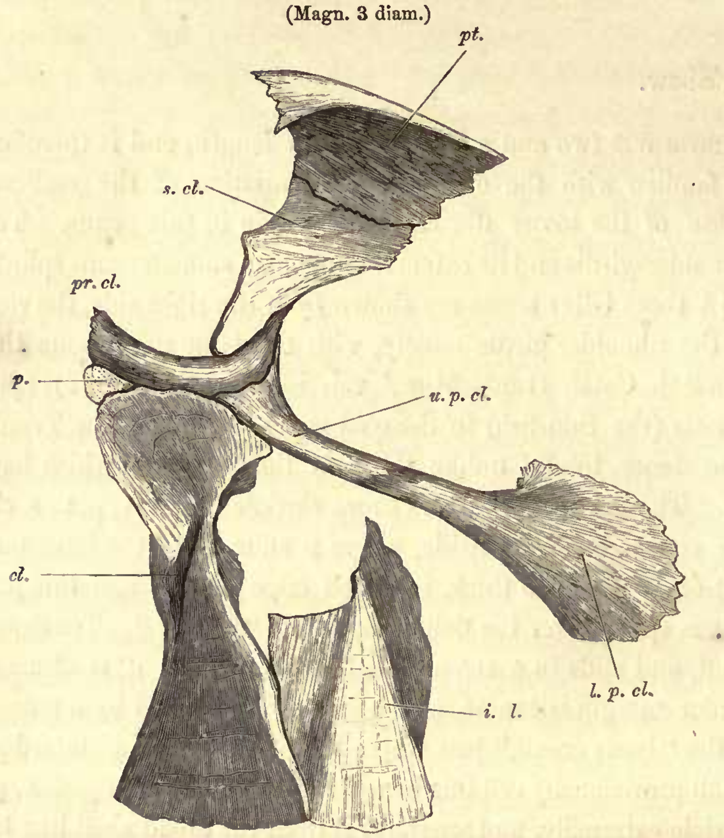


FIG. 4 B. Right coraco-scapular plate, and inter-clavicle; inner view.

(Magn. 3 diam.)

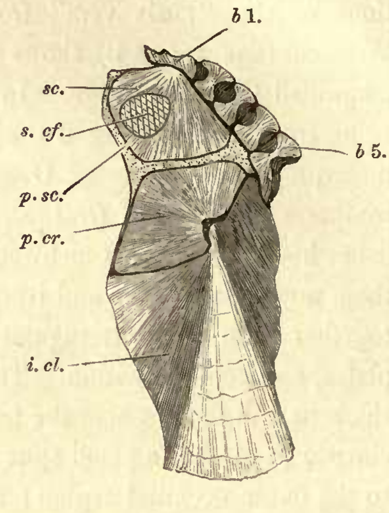
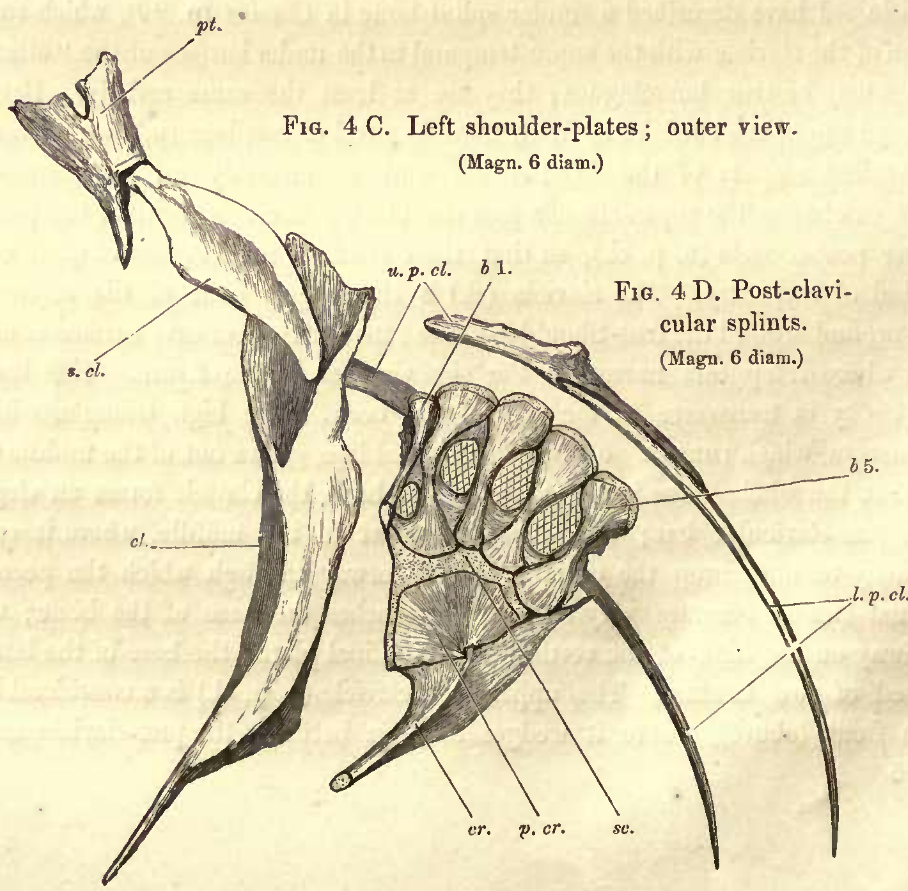


FIG. 4 C. Left shoulder-plates; outer view.

(Magn. 6 diam.)

FIG. 4 D. Post-clavicular splints.

(Magn. 6 diam.)



pointed behind and below, where it clamps itself on to the outside of the next piece. This second post-clavicle (l. p. cl) is narrow and pointed above, and then soon spreads into a broad trowel of bone, which stretches half way from the oblique pectoral opening to the end of the curiously tesselated ganoid box. The lower and hinder part of the fore-and-aft down-growth of the clavicle seems to answer to the distinct "anterior inter-clavicle" of *Syngnathus;* but the posterior inter-clavicle of that Fish is represented in *Ostracion* by a very large bone (figs. 4 A, 4 B, i. cl.), having three wings, bent on each other at a very obtuse angle.

The broad, slightly arcuate base of the interclavicle rests on the abdominal line, close behind the clavicle; it grows upwards as a high but regular triangle, with a rounded apex. The posterior margin of the clavicle leans forwards, and the anterior wing of the inter-clavicle widens upwards to be attached to it; this thin wing, free from the growth-markings of the middle part, ends almost horizontally above. The posterior wing is separated from the main part by a deepish sulcus; it is lanceolate, sinuous behind, and runs upwards above the middle part into a point, which wedges in between the præ-coracoid and lowest "brachial" (fig. 4 B, i. cl., p. cr., b. 5). This pointed plate and the rounded end of the main triangle are anchylosed to the posterior margin of the præ-coracoid, reminding one of the Siluroids; but the gently in-turned front wing is permanently free from the base of the coracoid, their mode of junction being by "harmony," and there is a very narrow but clear chink between them.

The scapula of *Ostracion auritus* (fig. 4 B, sc., p. sc.) forms nearly half of the Shoulder-girdle moiety; the other half being the præ-coracoid (p. cr.). The whole plate is large, oblong, and bent forward in such a manner as to leave a very open angle in the front margin. Along the front margin there is a selvedge of clear cartilage, and passing through between the two bony plates there is a considerable band, largest at its ends, quite uncovered with bony substance. The shape of the scapula is roughly pentagonal; it is divided into a scapula proper (sc.) and a præ-scapula (p. sc.), the latter being the narrowest; this division, which is arrested, is made by a transversely egg-shaped fenestra (sc. f.), the apex of which is directed backwards. The "glenoid" margin is thick, and it is here that ossification commences in an "ectosteal" plate, clamping the cartilage by an outer and an inner extension; these plates are arrested in front and below. The præ-coracoid (p. cr.) is an elegant rhomboid, with the posterior margin notched to receive a peg from the inter-clavicle; at this point, and a little above and below it, there has been anchylosis of the great underpropping splint with the ectosteal selvedge of the back of the præ-coracoid. Like the scapula, this præ-coracoidal element is only feebly ossified, except at the hinder margin; the bony-plate has grown but little into the substance of the cartilage.

If I had surveyed these parts fresh from the typical Fishes they would have caused me much trouble; but the way has been made much smoother by my coming to them through by-paths. We have seen this coalescence of parts of the outer and inner skeleton, and shall see it again, and it is noteworthy that, although the splint-bones are ready enough to coalesce with endo-skeletal bones, yet, retaining their old nature as scales, they are very slow to combine with each other. The *affinity* of the dermal system for the endo-skeleton becomes stronger and stronger as we ascend the vertebrate scale; and in the warm-blooded classes the most remarkable metamorphic combinations take place. The most careful microscopical observation of the inter-clavicle (i. cl.) of the young *Ostracion* reveals no trace of cartilage-cells within it although the scapula and coracoid have their cells, for the most part, unchanged between the ectosteal plates.

I think, therefore, that the coracoid proper has been completely aborted by this large and precocious inter-clavicular splint, although in the other types of the Plectognaths the existence of this splint is doubtful, the place being evidently supplied by periosteal growths from the large coracoid.

The brachial series of bones (fig. 4 B, b. 1—5) are much more strongly ossified than their scapular foundation; there are five of them, and all but the upper are elegantly hourglass-shaped; the upper bone is very irregular, oblong, and notched; they occupy the whole posterior margin of the scapula and præ-coracoid. The inter-clavicle wedges itself between the lowest bone and the præ-coracoid, the lowest brachial sending down behind it a long periosteal process. They are all rich in these outgrowths, and the narrowing of the waist of each bone arises from an arrested cleavage into a præ-brachial and a post-brachial series; the ectosteal sheath of the bone fits to the contained cartilage, like a pair of corsets.

Example 2.—Tetrodon ——— ?

The small Spiny Globe-fish from which my dissections have been made[1] measures less than three inches in its entire length. The Woodcut (figs. 4 C, 4 D) shows the outer and inner parts of its Shoulder-girdle magnified six diameters, and the endo-skeletal elements are depicted as somewhat disarticulated from their investing splints.

In this instance, as in the *Ostracion*, the ossifications (ganoid spines) formed in the skin are quite irrelative to those found in the subcutaneous tracts and in the aponeurotic septa, and which are, by a sort of morphological affinity, correlated with the true skeleton. The splint-bones are very fibrous, and the endo-skeletal parts are but feebly ossified. The post-temporal (fig. 4 C, p. t.) is a triangular bone, the base of which is attached firmly to the angles of the occiput, whilst its apex is produced outwards and backwards; behind this spur there is a condyle for the supra-clavicle, and on the upper margin the bone is notched. The supra-clavicle (s. cl.) is not unlike the blade of a pruning-knife, its point being directed downwards, its sharp edge looking forwards; its crescentic postero-superior edge is thickened, and the part to be joined to the "haft" is the condyle, which is articulated with the supra-temporal; whilst the blade lies obliquely in the upper fossa of the clavicle. This latter bone (cl.) is normal, and like many other Fish-bones is developed into wings. Of these there are three—one growing inwards, concave in front; another outwards, convex in front; and these together form the bony door to the hinder part of the gill-opening. The third plate grows backwards; it is convex on its outside and concave within; it is deficient both above and below, and is attached behind to the true Shoulder-girdle. Below, the clavicle ends in a long style; above, it is scooped in front, and is obliquely emarginate. Behind this part is the "upper post-clavicle," it is a gently curved style (figs. 4 C, 4 D, u.p.cl.) with an upper snag at the middle, and having the lower half scooped in front for the bone below. This next bone is the "lower post-clavicle" (l. p. cl.); it articulates to the outside of the lower half of the upper piece, and is an elegantly arcuate, slender style, which forms nearly a right angle with the clavicle, and reaches as far downwards; these bones lie within the true shoulder-plates (fig. 4 C.)

It is not easy, at first, to see the meaning of the true Shoulder-bones in the *Tetrodon*, for it has made a great stride towards the typical Fish, as may be seen by comparing it with the

[1] The gift of Dr. Günther.

Ostracion. The whole of each moiety (fig. 4 C, sc. cr.) is, as far as its cartilaginous basis is concerned, of a very peculiar form; denuded of its periosteal layers, it would be in the form of a Fan-palm leaf, with the blade bent forwards on the stalk. The broad blade has a nearly straight anterior margin; below, also, the base of the blade (sc. p. cr.) is nearly straight, and the stalk of cartilage, which is extremely delicate at the top, is set on behind the middle. The posterior margin is strongly crenate, being cut into four crescentic notches ("glenoid notches") for four of the brachial rays. The upper notch is the largest, the lowest next in size, and the upper but one the smallest; this coincides with the different dimensions of the proximal ends of the brachials. There is no "scapular fenestra," nor, indeed, scapular ossification; but this region, save where it is trespassed upon from below by the præ-coracoid (p. cr.) is entirely unossified, and a soft tract of hyaline cartilage forms a headland in front of and behind the præ-coracoid. This latter element (p. cr.) is fan-shaped; it is flat in front, convex behind, and hollow in the middle,—that is, as it is seen from the outside; the ossification is very much arrested, and but few of the cartilage-cells are affected by the inner and outer "ectosteal" laminæ. This specimen is either of a small kind, or is the young of a larger one; in either case the ossification would be less intense than in a large specimen. The coracoid (cr.) has been very nearly segmented from the præ-coracoid, only a slender rod of cells connecting the two regions. This delicate style of hyaline cartilage thickens gradually in its lower parts, it is invested with a much stronger ectosteal sheath than the præ-coracoid, and from the long styloid sheath wings project, both fore and aft; these turn inwards, and form but little more than a right angle with each other. The bony matter of the two regions is continuous where the "stalk" joins the "leaf," but nowhere else; for the "wings" of the stalk-like coracoid are entirely unconnected with the præ-coracoid; a clear chink can be seen both in front and behind (fig. 4 C, p. cr., cr.) There now arises a curious and, to me, an unexpected difficulty; for the periosteal wings which grow out from the rod-like coracoid take the place of the "inter-clavicle" of the *Ostracion* (fig. 4 A, i. cl.). If my descent upon this type had been made from the common Fishes I should have suspected nothing beyond what is apparent; but fresh from the Siluroids, the Lophobranchii, and the *Ostracion;* and aware of the atypical characters to be seen in *Gasterosteus*, soon to be described, I am prepared to believe that there is more in the coracoid of the *Tetrodon* than meets the eye. The coracoid proper is aborted by the large aponeurotic "inter-clavicle" in *Clarias*, *Ostracion*, and *Gasterosteus;* but in *Cottus bubalis* (Plate II, fig. 12, p. i. cl.) the principal inter-clavicle lies close on the inside of the coracoid, but quite free from it. Then we have seen its presence and its independent condition in *Syngnathus* (Woodcut, fig. 3 A, p. i. cl.), and, therefore, it is quite possible that there may have been a distinct inter-clavicle in an earlier stage of this Fish the *Tetrodon*. This view is strengthened by the fact that these two elements are very apt to coalesce. On the other hand, any one familiar with the structure and development of the endo-skeleton of the Teleostei knows how apt the ectosteal sheaths of cartilaginous rods are to shoot out into large wings; a beautiful instance of this is seen in the interspinous rays, especially of such a Fish as the Dory (*Zeus*). Thus there seems to be no absolute necessity to suppose that the double ectosteal laminæ of the præ-coracoid and coracoid were ever distinct in *Tetrodon*; they are in several Families of the Malacopteri; but the *Tetrodon* conforms rather to the Acanthopterous type. Undoubtedly, the isthmus between the præ-coracoid and the coracoid was very much wider at an early period than in this stage, which I am now describing, so that the first bony investment of the cartilaginous plate would commence at the isthmus itself, and then, growing like a bent and flattened hourglass, would, by spreading into a fan above, and developing the inturned wings below, ultimately come to assume the form here figured and described.

There are five brachial rays, four of which apply their lunate bases to the crenate "glenoid" margin of the Shoulder-blade; it is the uppermost but one which has aborted the scapula. The uppermost ray is much the smallest; it is pointed in front (fig. 4 C, b. 1), and actually bends round to apply itself to the front of the starved scapular cartilage. The four larger rays are flattened hour-glasses; they have soft ends, and lanceolate interspaces; and they are perfectly cloven from each other. The elegant interspaces are lessened by transverse periosteal, spicular growths, especially proximally; the free edge of the upper and of the lower ray is rendered jagged by similar growths. A comparison of the Shoulder-girdles of *Ostracion* and *Tetrodon* will show how widely apart these two types of Plectognaths lie.

Example 3.—*Triacanthus* ——— ?, sp.

The family Balistidæ brings us much nearer to the typical Acanthopterous Fishes, and I shall merely give the general characters of the Shoulder-girdle in this group. My observations have not been made from fresh dissections, but from some excellent skeletons in the Hunterian and British Museums. In the former there is one of an unnamed species of *Balistes* ('Osteol. Catal.,' vol. i, p. 76, No. 326), and also of *B. forcipatus*, Will. (No. 327); in the latter there is a preparation of a *Triacanthus*, another of *Balistes aculeatus*, Linn., from the Mauritius, and two others of the genus *Balistes*, the species not known. These skeletons show stronger bone than is seen in *Tetrodon*, and there is a great approach to the skeleton of the Dory (*Zeus*); the bones are, however, feebler and more fibrous than in that type. A description of the Shoulder-bones of *Triacanthus* will serve for the rest.

The "post-temporal" is flat, and closely adherent to the occipito-temporal region, as in *Zeus*, *Tetrodon*, *Lophius*, &c. The "supra-clavicle" is rather small and styloid; the clavicle is quite normal, and not unlike that of high-bodied Fishes generally; the "post-clavicle" agrees, not with that of the *Tetrodon*, but with that of the Dory (Plate I, fig. 14, p. cl.). It nearly meets its fellow below at a great distance from the clavicle; it is strong, straightish, and is expanded above, where it is tied to the inside of the clavicle. The Shoulder-plate itself is relatively large, and there are only two ossifications in the adult Fish; these are the "scapula" and the "coracoid." The former of these is fenestrate, and is thus partly divided into a "præ-scapula" and "scapula proper," as in nearly all truly typical Fishes. The latter—the "coracoid"—has a broad subquadrate "præ-coracoidal" portion obscurely marked off from the long, large-winged "coracoid proper;" the anterior wing is the broadest. The coracoids end near the abdominal line, like the clavicles and post-clavicles.

Fam. "GASTEROSTIDÆ."

Example.— Gasterosteus leiurus, Cuv. and Val.

I have long been familiar with the skeleton of such "Mailed-cheeked" Fishes as the *Triglæ* and the Cottoids; but my attention has lately been directed to the Sticklebacks (*Gasterostei*). Professor Huxley some time since ('Proc. Royal Soc.,' Nov. 18, 1858; and 'Microscop. Journ.,' Oct., 1858, vol. vii, pp. 33—46; and Jan. 7, 1859, pl. iii) worked out some most valuable results from the commonest kind, viz, *G. leiurus.* His researches have had regard to the development of the skull and of the tail; this latter part of the Fish is shown to be truly "heterocercal;" and in the figure given of the face of the adult Fish ('Croon. Lect.,' p. 27, fig. 7) I long ago detected an instance of connation, very remarkable indeed if this be a typical Acanthopterous Fish. I refer to the palatine bar (*pa.*), which has no separate "pterygoid," but at once articulates with the "quadratum" (*Qu.*). My present remarks are upon the Shoulder-bones of the adult Fish, and they satisfy me that this is not one of the ordinary Acanthopteri; I shall therefore consider them as belonging to a very special Family, but leave the Order in which they should be placed to some other Ichthyotomist.

Altogether, the morphology of the dermal skeleton of *Gasterosteus* carries us back again to the same ichthyic level as the Siluroids; the Lophobranchii and the Plectognathi come much nearer to the typical Fishes, and thus diverge much further from the true Ganoids than these familiar little denizens of our fresh-water pools and canals. The Ganoidei are hemmed-in on all sides by Genera and Families of Fishes that are aberrant from the higher types; none of these press much nearer to those ancient Fishes than the Sticklebacks. There are scarcely any morphological characters that express *generalization* in the Fish-Class better than connation of dermal plates with ossified subcutaneous tracts, and coalescence of these bony parts with true endo-skeletal elements; both these characters are well exemplified in the *Gasterostei.*

The "post-temporal" (fig. 5 A, p. t.) is a fan-shaped ganoid plate, strongly articulated to the outer angle of the occiput; it has a strong subcutaneous peg at its antero-inferior angle. The "super-clavicle" is not distinct from the clavicle, a character seen in *Clarias;* in one side of *Callichthys;* and in *Syngnathus.*

The clavicle (cl.) is continuous with the supra-clavicle and is very large; it is connate with a quadrant-shaped ganoid plate, from the hinder part of which there projects a sharp spur, and along the front of which the supra-clavicular bar runs upwards and forwards. The body of the bone proceeds downwards and forwards from the base of the upper spur, and from the sharp and serrated lower edge of the ganoid portion; it is a thick rod, with a long, sinuous, concave wing in front, and a shorter convex wing externally. The clavicle reaches nearly to its fellow below, and articulates with the anterior angle of the inter-clavicle (i. cl.).

Above the ganoid part of the clavicle there is a small oval ganoid ossicle (fig. 5 A, l. l. 2); this belongs to the second thoracic cincture; it answers to the second lateral-line bone, and is the serial homologue of the "post-temporal." The next ganoid plate (fig. 5 A) is more like the post-temporal, but is not half its size; it is perforated by a mucous duct. The next is oblong, with triangular ends, and much larger; it answers, in its own cincture, to the post-temporal and

SHOULDER-PLATES OF GASTEROSTIDÆ, AND COTTIDÆ.

FIG. 5. A, B. GASTEROSTEUS. C. COTTUS.

FIG. 5 A. Left shoulder-plates and lateral-line bones; outer view.

(Magn. 9 diam.)

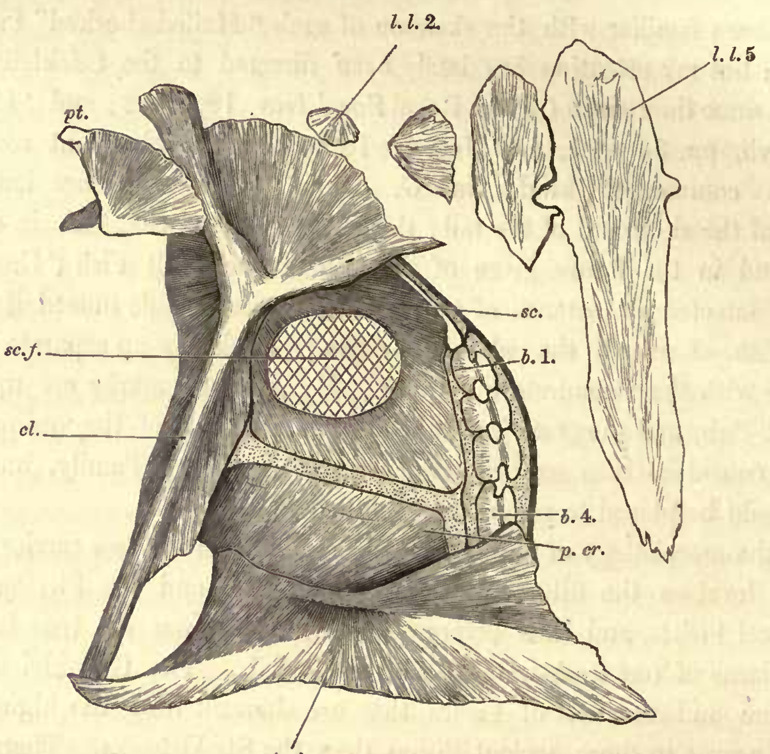


FIG. 5 B. Inter-clavicular plates; lower view.

(Magn. 9 diam.)

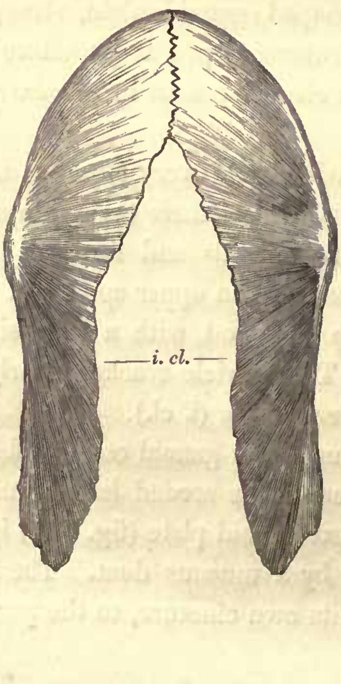
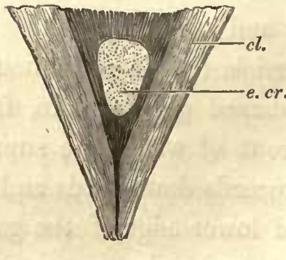


FIG. 5 C. Section of lower part of Shoulder-girdle; front view.

(Magn. 10 diam.)



supra-clavicle in one piece. The fifth plate (the first is the post-temporal), reaches higher up, is, like the last, *over*lapped by the dorsal-line plates, and grows downwards some distance *within* the large infero-lateral plate connected with the ventral fin. There are three more such plates in this species, (*G. leiurus*), the last being somewhat smaller; they overlap each other from before backwards. The fifth and succeeding ganoid plates answer to the post-temporal, supra-clavicle, and clavicle—all in one piece; they are united by strong bony pegs, and are perforated by mucous ducts; and they answer, in the mucous region, to the lateral-line bones of the ordinary Teleostei. This division of the lateral plates is very different from what is seen in *Callichthys*, in which the plates divide close below the mucous ducts (see Plate I, fig. 9, s. l., 1—4).

I see no plates of bone in this species that belong to the middle part of the second cincture, the bones of which are evidently absent because of the overgrowth of the clavicle and inter-clavicle. Nearly the whole of the thorax and abdomen is invested below by two pairs of huge infero-lateral ganoid plates. These are the inter-clavicles (fig. 5, A, B, i. cl.) and the plates that are correlated to the ventral fin; thus, the Shoulder-girdle and the Hip-girdle attract to themselves, below, large ganoid, dermal Breast-plates, that are serially homologous, and that equally run wild over the lower part of several Somatomes. My business, at present, is with the anterior pair (i. cl.); and these will be found to have grafted themselves upon the true Shoulder-girdle, showing that they are as much correlated to this part of the endo-skeleton as the clavicles themselves. If these bones be compared with those of the Sturgeon (Plate I, figs. 6—8, i. cl.) it will be seen that they are almost precisely alike; the ganoid, outer portion sending inwards, from its upper edge a thin but broad lamina; but there is an important difference. In the Sturgeon this inner part is subcutaneous, and is a continuation of the bony hinder wall of the gill-opening, the upper part of which is formed by a similar plate growing from the clavicle. In the Stickleback it is an aponeurotic plate, which lies within the muscles of the shoulder and becomes soldered to the lower edge of the præ-coracoid.

The true Shoulder-girdle is of very great relative breadth in *Gasterosteus;* and it is anchylosed above, in front, and below to the large exo-skeletal plates; but as these aponeurotic laminæ are connate with the ganoid plates, this little Fish agrees with the Siluroids, and not with the Ostracioids, in which the ganoid plates are entirely differentiated from the aponeurotic ossifications: this is a great stride towards the typical Teleostean skeleton. The broad, thin scapula (fig. 5 A, sc.) is well ossified, save towards the coraco-scapular synchondrosis; very much of its substance disappears in the middle, for its "fenestra" (sc. f.) is very large; this is a transversely oval space. The general outline of this plate is five-sided, narrowing towards the top, both fore and aft; its largely extended base is nearly straight, and is directed a little downwards as well as backwards. A considerable space of unchanged hyaline cartilage intervenes between the base of the scapula and the upper surface of the coracoid, and in this region the scapula has a core of soft cartilage. The arcuate front margin is anchylosed to the posterior plate of the clavicle; the supero-posterior margin is straight, and, like the posterior edges of the brachials, is considerably thickened; the infero-posterior margin is very thin, joins the upper part of the selvedge by a very obtuse angle, and, being the glenoid region, it articulates with three of the brachials. Behind the supero-posterior margin there is a band of flat-celled hyaline cartilage, which is continued down behind the brachials, and it is only partly divided by a curving inwards of the cells towards each inter-osseous space. The præ-coracoid (p. cr.) is a transversely oblong bar, the upper margin of which is formed by the double ectosteal plate which clamps and encloses the lower part of the cartilaginous interspace between this part and the scapula. It evidently began to ossify at the lower selvedge, and here it has become fused with the aponeurotic plate of the interclavicle (i. cl.); its upper angle, behind, is more than a right angle, and the unchanged hyaline cartilage continues down behind it, forming the glenoid space for the lowest brachial (h. 4). Here, as in the genus *Clarias* (fig. 2 A, cr. i. cl.) and as in the *Ostracion* (fig. 4 B, p. cr. i. cl.), there has been considerable abortion of the body of the coracoid, caused, as it would seem, by the potent development of the correlated splint-bone.

There are four brachials, not differing much in size, but the uppermost is the smallest, and the lowest but one the largest. They are bounded by a band of soft hyaline cartilage, both before and behind, and the hinder band runs up behind the scapula; the segmentation is arrested in this selvedge. So also is the segmentation into a præ-brachial and a post-brachial series, and the "fenestræ," which are arranged in a vertical line, only serve to notch these rays; the hinder edge of each ray is turned outwards, so that the pectoral *dermal* rays turn outwards as easily as they lie backwards. What I have been describing in no degree answers to a Sclerogenous Fish, like a *Cottus* or a *Trigla*, for their large brachials abort the coraco-scapular band; and they show no tendency to coalescence of exo- with endo-skeletal elements. But this genus does not properly belong to the Thoracici; *it is an "Abdominal" type*. The large *ventral* bones, to which the ventral fins are attached, are not ischio-pubic elements, but *sub-mesial* abdominal *ganoid scutes;* the serial homologues of the large inter-clavicular scutes. Each abdominal fin, in this and several other species, is composed of one highly barbed dermal spine, and this articulates partly with the abdominal scute; close beneath its ascending portion; and partly, like the pectoral spines of the Siluroid, with the endo-skeletal bone; this inner bone is the true "ischio-pubic" plate, which is foreshortened in front, *articulates by suture* with its fellow, and becomes anchylosed to the dermal plate outside (exactly as in the union of the coracoid and the inter-clavicle, and also of the scapula and clavicle). Moreover, I find that the ventral fins are set on further backwards than in *Callichthys littoralis;* in that Siluroid the "cotyloid" articulation—*i. e.* of the ventral fin with the "ischio-pubis"—is between the fourth and fifth ganoid thoracic cincture, but in *Gasterosteus leiurus* it is between the sixth and seventh, and the distance between the anterior end of the pubis and the base of the clavicle is one third of an inch, or as far as the upper part of the preopercular bone from the snout. I need not remind the reader that the ends of the "pubes" lie between the lower part of the clavicles in *Cottus*, *Agonus*, *Gobius*, and in the Acanthopteri generally. I shall make no apology for taking this Genus from amongst its false relatives, and placing it side by side with the Siluroids, in close proximity to the old Ganoid types; meanwhile, however, it would well repay the morphologist who would work out the rest of the osteology of this type, especially if it were done in a developmental manner.

I must now turn to the higher types, the "Pisces Acanthopteri" of Müller; but this Order might be divided into an atypical and a typical assemblage. The former should take in the Trigloid, Cottoid, Gobioid, Blennioid and Lophioid Families; all these are more or less aberrant, and come into proximity to the *Sub-ganoid* types, and even to the true Ganoidei.

Fam. Cottidæ.

Example 1.—*Cottus bubalis*, Euphrasen.

My first instance is the best connecting link between the Ganoid and Sub-ganoid types already described and the true typical Teleostei, the Percoids and their allies; moreover, another Cottoid—the Pogge (*Agonus cataphractus*)—reassumes the ganoid covering. In the Fatherlasher (*Cottus bubalis*), I first saw that the so-called supra-scapula was nothing more nor less than the first "lateral-line" bone, connecting that series with the "supra-temporals." Plate II, fig. 12, s. t., is the last of that series; and p. t. is the "post-temporal," a scabrous scale, which is two-legged, and is attached in the usual manner to the occipito-otic region. There is a much larger bone below this, the "supra-clavicle" (s. cl.); it is rough at the top, and sends downwards and backwards a large flat blade; this blade is tied obliquely across the scooped upper part of the huge clavicle. This latter bone (cl.) reaches nearly as high as the vertebral spines, whilst below it meets its fellow of the opposite side at the abdominal line. Below the obliquely scooped upper part of the clavicle the bone looks forwards and inwards, and for some distance there is very little posterior growth; below the scapula this posterior plate begins, and is very strong; it increases in breadth very rapidily towards the lower part. This lower, longitudinally vertical plate of the clavicle answers to a great degree to the inter-clavicular plate of the *Ostracion* (fig. 4, A and B, i. cl.), and to the two inter-clavicles of the *Syngnathus* (fig. 3 A, a. i. cl., p. i. cl.); but not altogether, for there are two additional ossicles (Plate II, fig. 12, a. i. cl., p. i. cl.) in *Cottus bubalis*. The first of this, the "anterior inter-clavicle," is a small oblong bone, occupying the posterior angle of the plate; the "posterior inter-clavicle," is a much larger plate; it is oblong, with a produced point below; these plates are all on the *inside* the coracoid. Here we see that the *Cottus* is ascending in the scale towards the typical Fish; and these feeble inter-clavicles are to a great degree aborted by the main clavicle; and have no power to arrest the coracoid in the manner shown in *Gasterosteus* and *Ostracion;* yet their presence is to me most unexpected, and very instructive. The post-clavicle (p. cl.) is a rather feeble, gently arcuate, and bluntly styloid bone; it reaches to the middle of the brachial series below. The scapula of *Cottus* (sc.) is largely cloven in front by an obliquely oval notch (sc. n.); above, it articulates (by harmony) with the posterior edge of the clavicle; below, it rests its squared base upon the top of the great posterior plate of the clavicle; behind, it sends a periosteal layer over the two upper brachials. It is wholly separated from the top of the præ-coracoid for the whole space, and more, of the depth of the greatest brachial; the lowest but one (see Plate II, fig. 12, sc. cr.). The four uppermost (dermal) pectoral rays (p. r.) articulate directly with the scapula, and its posterior or glenoid margin, receives the two upper brachials (b.). Both the scapula and coracoid are converted into dense bone in *Cottus bubalis;* the latter bone sends upwards a narrow glenoid band (p. cr.), and this part forms an obtuse angle with the head of the bone; into this angle the lowest brachial (b. 4) fits. Where the præ-coracoid and coracoid regions unite at an extremely open angle, the coracoid foramen (cr. fo.) is seen; the main part of the bone is a phalangoid ray; it is broad at the base, nearly reaches the bottom of the clavicle, and lies in the right-angled space between its front and hinder plates.

But there is another segment into which the Shoulder-girdle moiety is divided, viz. the epicoracoid; this is not shown in fig. 12 of Plate II, but is shown in the Woodcut (fig. 5 C, e. cr.) in *Cottus scorpius*, Bl. I have already described this part in the *Lepidosiren*, where it is largely developed, but I only lately came across this part in the Teleostei. The Shoulder-girdle moiety in these Cottoids, and in other Fishes with huge pectoral fins, is subject to a remarkable form of segmentation; first, the large brachials grow through the glenoid part, dividing the scapula from the præ-coracoid, and then the clavicle *passes between* the foot of the coracoid and the epicoracoidal mass. The splint-bones ossify at a very early stage of the embryonic Fish; and, undoubtedly, whilst the cartilage is in a very soft condition, before the deposit of the inter-cellular substance. The Woodcut (fig. 5 C) shows a section of the lower part of the two clavicles (cl.) and in that acutangular space is seen the epicoracoid mass (e. cr.) which belongs to both sides of the body, although the divisional line cannot be seen in this case; it can be seen, however, in *Gobius niger*. This breaking-up of the coraco-scapular plate in the Fish Class is curious enough, and is not seen in the air-breathing, cold-blooded Ovipara.

The four brachials of *Cottus bubalis* (Plate II, fig. 12, b. 1—4) are large, squarish, flat, smooth bones, and are highly ossified; the lowest but one is the largest. There are three small, vertically oval fenestræ, the uppermost of which lies between the small, irregular, upper brachial and the scapula. Altogether, the skeleton of *Cottus bubalis* is most intensely ossified, and the Shoulder-girdle and arm partake in this strong calcification; but the morphological characters in my region of this Fish are interesting in the highest degree, and a thorough knowledge of them is no mean help towards a true appreciation of the homologous parts in the entire Class.

Example 2.—Agonus cataphractus, Linn.

The Armed Bull-head, or Pogge, is a curious isomorph of the *Hippocampus*, and may be said to lie somewhat between the Cottoids and the Lophobranchii, although agreeing much more with the former than with the latter.

The ganoid armour of this Fish is combined with a weaker skeleton than that of *Cottus bubalis*. The clavicle of *Agonus* is much broader than that of Cottus, and the outer part of the large anterior plate is directed backwards, instead of forwards as in *Cottus;* the posterior plate is less developed, and I fail to find the smaller inter-clavicle. The post-clavicle is a feebler style. The scapula has a large, obliquely oval "fenestra," and it is continuous with the præ-coracoid below, there being a "glenoid," band of cartilage uniting the two regions.[1] The coracoid and præ-coracoid are very similar to those of *Cottus;* but the whole piece is less strongly ossified. The epicoracoid is larger than in *Cottus scorpius*, and it was in this species that I first saw a Teleostean repetition of what I had until then only seen in the *Lepidosiren*.

The brachials are still relatively larger than in *Cottus*, but there are only three; the middle bone is the largest, for it is the uppermost bone which is aborted. These bones have a considerable margin of cartilage behind; and they are well segmented from each other.

[1] In the Gurnards, also, the coraco-scapular band of cartilage is only partly aborted, and their epicoracoid degenerates into a fibrous mass.

Fam. GOBIIDÆ.

Example 1.—*Amblyopus* ——— ?

My specimen of this tropical Gobioid Fish[1] measures 20 inches in length; the Woodcut (fig. 6A) shows its Shoulder-bones—of the left side and part of the right; magnified two diameters.

The post-temporal (p. t.) has a small, flat body, with a hinge below for the splint beneath it; and two long forks. The supra-clavicle (s. cl.) has the normal spatulate form, with the oblique condyle above for the supra-temporal; it overlaps by its flat lower end the forked top of the clavicle. The clavicle (cl.) has two flat spines at the top, the front one reaching furthest upwards; it is a large, sinuous, ridgy bone, bent suddenly below the upper third, and presenting a narrow but deeply grooved front towards the gill-opening. Behind, it sends an upper posterior plate, which lies in front of and slightly external to the præ-coracoid (p. cr.) and middle brachials (b.). More than the upper half of the lower third gives off an ear-shaped "inter-clavicular process," (i. cl. p.) *in front* of which is seen the body of the coracoid (cr.). The clavicle widens below, is subangular, convexo-concave on the outside, and scooped within to receive the epicoracoid cartilage (e. cr.). The post-clavicle (p. cl.) is a slender, but strong style; it is attached within the head of the clavicle; and is considerably smaller than that of *Cottus* (Plate II, fig. 12, p. cl.). As in *Cottus*, the Shoulder-girdle moiety is segmented into three parts, all wide apart; the first cleft being dependent upon the excessive growth of the middle brachials (b.); and the latter caused by the intrusion of the large clavicle. The scapula (sc.) is a very small bone; it is a low triangle, with the base attached to the clavicle, and the upper angle notched; it causes an emargination of the glenoid edge of the uppermost brachial (b. 1), with which it is strongly clamped by means of periosteal layers, but from which it is persistently separate. A space more than the length of the scapula intervenes before we reach the pointed, unossified upper end of the præ-coracoid (p. cr.). This part is nearly in a line with the body of the coracoid (cr.), which is flat, but stout, and forms one bone with the base of the præ-coracoid. The lower end of the coracoid is soft; it is angular in shape and lies in the angle between the body of the clavicle and its "inter-clavicular process"—*on its outside.* The distal coracoid element—the epicoracoid (e. cr.)—is about the same distance from the end of the coracoid that the præ-coracoid is from the scapula; it is an oval, double plate of hyaline cartilage, and lines the smoothly scooped fossa, *inside* the distal end of the clavicle; so that the clavicle, in the adult, passes obliquely from the inside to the outside of the Shoulder-girdle elements, and it is very probable that the inter-clavicular process is a later growth than the body of the clavicle. As for the upper part of the clavicle, it simply lies in front of the scapula and coracoid.

The brachial rays (b. 1—4) are extremely large, very flat, and together form a semi-oval plate, the rounded edge being crenate, and the anterior edge straight, and applied to the shoulder-bones. This is not quite a straight margin, for it is notched above for the scapula; it bulges in the middle, where it reaches the clavicle, and has the lower third, which is applied to the præ-coracoid, straight. There is no actual division of the soft cartilage in front; behind,

[1] The gift of Mr. Waterhouse Hawkins.

THE SHOULDER-PLATES OF ACANTHOPTEROUS FISHES.

FIG. 6 A. AMBLYOPUS ; left, and part of right side. FIG. 6 B. GOBIUS ; front view of lower part of Shoulder-girdle. FIG. 6 C. BLENNIUS ; left side, outer view. FIG. 6 D. CHANNA ; right side, inner view. FIG. 6 E. MULLUS ; left coraco-scapular plate, outer view.

FIG. 6 A.
(Magn. 2 diam.)

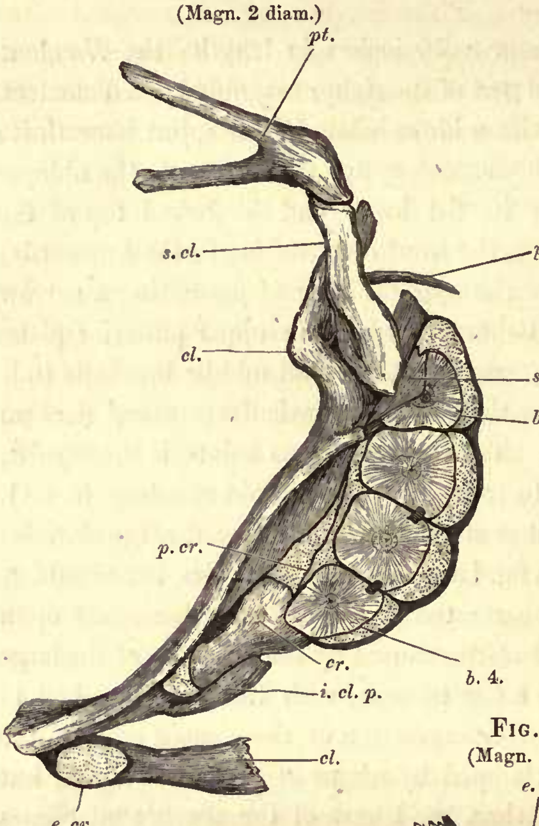


FIG. 6 C.
(Magn. 10 diam.)

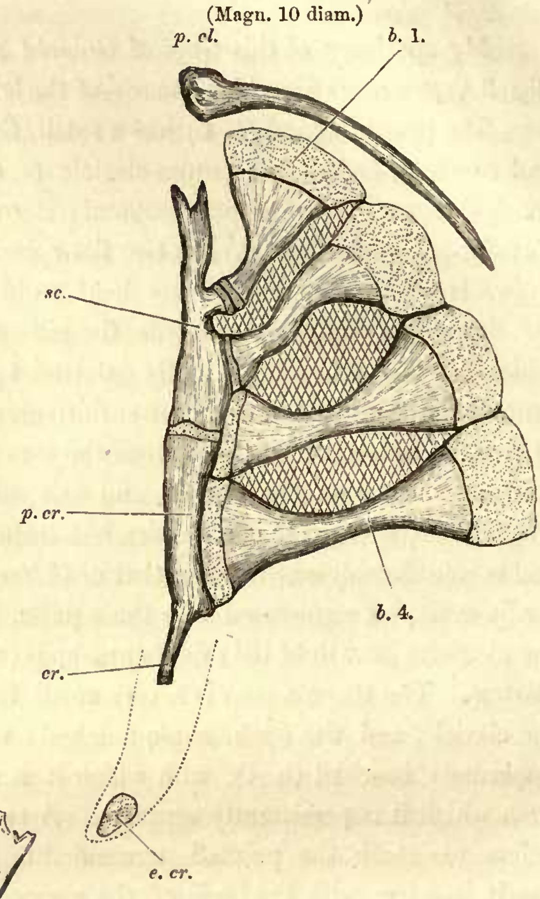


FIG. 6 B.
(Magn. 10 diam.)

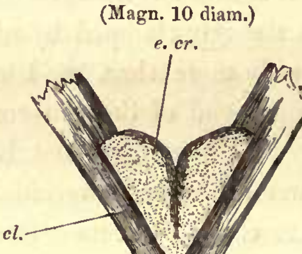


FIG. 6 E.
(Magn. 2 diam.)

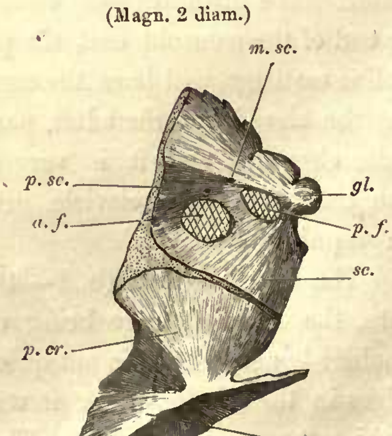
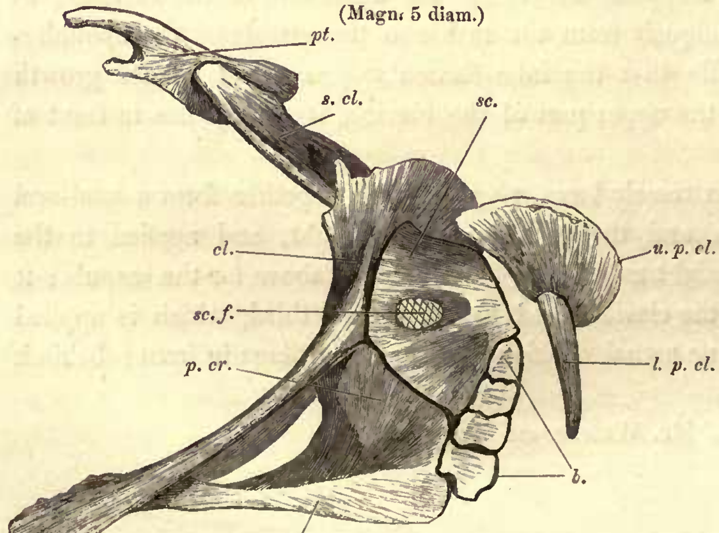


FIG. 6 D.
(Magn. 5 diam.)



however, the plate is elegantly four-lobed, and a considerable fissure passes forwards to the front third. The middle brachials would have been oval if their fission had been perfect; but the uppermost (b. 1) is almost triangular, and is notched in front, whilst the lowermost is somewhat lozenge-shaped. The vertical rudimentary clefts are very small; there is one notching the second and third, and another the third and fourth; they are nearer the posterior than the anterior margin. The ectosteal plates have met each other through the centre of the ray, but further outwards they are very thin, and enclose a thick core of soft cartilage, continuous with the common band in front and with their own marginal band behind. By comparing this figure with fig. 12, Plate II, it will be seen how near *Cottus* and *Amblyopus* come to each other in the structure of their Shoulder-plates.

Example 2.—*Gobius minutus*, Linn.

The true Shoulder-girdle and Arm of the Little Goby are shown in Plate II, fig. 13, magnified ten diameters. The proximal plate (sc., pcr. cr.) is a narrow band of partially ossified cartilage, the unchanged part being nearly as long as the two ossifications taken together. The bony scapula (sc.) is a peaked cap to this bar, the peak leaning backwards towards the arm-plate, and the base being pierced obliquely by the "scapular fenestra" (sc. f.). The "glenoid" coraco-scapular belt (gl.) is rather thick, somewhat variable in breadth, and is widest above and below, where it forms the soft core to the scapula and coracoid. This latter part (p. cr., cr.) has its præ-coracoid region half the length of the coracoid proper; they are nearly of the same width, and meet at a very open angle; the end of the coracoid is soft, and the cartilage fills the conical cavity of the ectosteal coracoid. In front and behind there is an "inter-clavicular wing;" the hinder wing sends upwards the usual spur. At a short distance below the coracoid, inside the grooved lower end of the clavicle, which is here indicated by dotted lines, there is a flap of soft cartilage, in shape a high triangle, with rounded angles below; this is the epicoracoid (e. cr.); there has been but one transverse cleft, in this case, in the Shoulder-girdle moiety.

The brachial plate is one piece of hyaline cartilage, with four bone-plots marked out in it; and with two arrested vertical clefts; these show the commencement of a division which, if perfect, would have resulted in the formation of a post-brachial as well as a præ-brachial series. The condition of this arm-plate, like the one in front of it, is very instructive; it represents *Amblyopus* in a much earlier stage of metamorphosis. In Plate II, fig. 14, a part of the middle transverse cleft is shown, magnified 100 diameters. The transverse row of intervening cartilage-cells is continuous; its cells are only flattened, and are partly hidden by "ectosteal" teeth (sutural serrations). At the lower left corner a patch of rounded cartilage-cells (c) is seen, showing that the ectosteal plate is deficient here and there, and also that it has not touched the underlying cells; for the cells seen as scattered over the surface, and transversely spindle-shaped, are bone-cells, formed in the ectosteal layer, altogether on the *outside* of the cartilaginous mass. Part of one of the fenestra (f.) is seen, the rest being hidden by the sutural flaps: these flaps are very common in the Fish-class, even when the ossification is incomplete; and these ectosteal growths are wont to spread into the fibrous tissues much more readily than into the cartilage which they invest; they have both a *centrifugal* and a *centripetal* direction of growth; but when the bony deposit affects the intercellular substance of the hyaline cartilage, it becomes "endostosis,"—*derived* when commencing from the inside of the ectosteal plate, and *independent* when it does not take its cue from that deposit. The semi-clefts between the posterior part of the brachials, as seen in *Amblyopus,* are not present here, the larger posterior band of cartilage being as continuous as that in front. The form of the brachials (b. 1—4) is much the same as in the large tropical type, the upper being sub-triangular, the lowest having an elegant fringed process of *outer* bone, which fills an emargination in the lower edge of the brachial plate; a triangular membranous space intervenes between this part and the notched top of the coracoid.

Example 3.—*Gobius niger,* Linn.

This larger native species of Goby differs but little from the small kind in its Shoulder-plates; but the ossification is more intense. I am able to show its epicoracoids *in situ* (fig. 6 B. e. cr.), and to assert that, although they are but little fused together on their inner face, yet they are not so free of each other as in *G. minutus;* they are also thicker.

Fam. Blenniidæ.

Example 1.—*Blennius pholis,* Linn.

The Woodcut, fig. 6 C, shows the left Shoulder-plates of the Smooth Shanny (adult), as magnified ten diameters. Dr. Günther ('Catal. of Acanth. Fish. in Brit. Mus.,' vol. iii, p. 213) failed to find the so-called "radius" and "ulna" in *B. gattorugine,* Will.; but this part, the coraco-scapular plate, is not at all deficient in these Fishes; it is, however, narrow, and very closely adherent to the posterior crest of the clavicle. The synchondrosis between the scapula (sc.) and the præ-coracoid (p. cr.) is very narrow, very much unlike what is seen in the Goby, and the whole plate is much more intensely ossified. The scapula (sc.) is very narrow above, and forked; it sends backwards a pedicle for the upper brachial (b. 1), is then very narrow, but soon expands to receive the next brachial and part of the lowest but one. The coracoid (p. cr., cr.) is of the same size as the scapula, the præ-coracoid forming most of it, which has the glenoidal region for the lowest, and half of the next brachial. The true coracoid (cr.) is very small, and projects but little forwards; a long distance intervenes before we come to the small oval epi-coracoid (e. cr.); its position on the inside the base of the clavicle is indicated by dotted lines. The post-clavicular splint (p. cl.) is twice as strong as in the Cottoid and Gobioid Fishes. The brachials are very large, and much unlike what we see, as a rule, in Fishes with large pectoral fins. The 1st (b. 1) is fan-shaped, so is the next, but bent in a sigmoid manner; the two lower rays are hourglass-shaped in outline; they all have a narrow cartilaginous proximal end, and distally they are soft to a great extent. They are entirely separated from each other, are more typical in shape than in the next instance, and also than in the *Triglæ, Cotti,* and *Gobii;* altogether they form a connecting link, morphologically, between the lower and higher types of the Acanthopteri.

Example 2.—*Anarrhichas lupus*, Linn.

Morphologically the Wolf-fish is below the true Blennies; it is more aberrant from the typical Fish, and the Shoulder-girdle is in a much more arrested condition. The post-temporal is not forked; the supra-clavicle is more than twice its length; this latter bone is thick above and in front; for the greater part it is thin and extremely fibrous, and of great breadth. The clavicle is a thick style above; then the thick front part sends back a triangular plate like the supra-clavicle, but with its thin fibrous margin looking upwards instead of downwards. In front it is thick on the inside; outwards it is knife-like. At the middle, behind, there is a small plate for attachment to the Shoulder-girdle; below that, and further inwards, there is a small inter-clavicular process. Below, it is rounded, and on the inside there is a scooped part, half an inch high and a quarter of an inch broad, for the epicoracoid cartilage, which evidently exists in the fresh state. The post-clavicle is either very small or absent. Nearly half of the scapula—its upper part—is ossified; it is fenestrate; its cartilaginous part ends below in two free points. At some great distance from this part is the coracoid; its præcoracoid part is broad, and the proper coracoid very short. The brachial plate is in the same morphological condition as that of *Gobius minutus* and *G. niger*, being unsegmented, save by the double ectosteal plates and their vertical fenestræ. There are four bone-plates, the upper the smallest, the lowest but one the largest; across this region the width, in an average specimen, is one inch five lines; the whole length (height) is two and a half inches, the greatest thickness two lines.

Fam. "Lophiidæ."

Example.—*Lophius piscatorius*, Linn.

This is a very low type of Fish—a long way below the typical Acanthopteri. Professor Owen ('Catal. Hunt. Mus.,' vol. i, p. 73, No. 309) says that the scapula and supra-scapula (supra-clavicle and post-temporal) are confluent. This is a mistake; the latter is quite distinct from the former, is not bifurcate, and fits, by a squamous suture, to the occipital region. The very small scapula and coracoid (the former a fenestrate bone) have, indeed, coalesced with the clavicle (see 'Owen's Lectures,' vol. ii, p. 121, fig. 40, 52, 54, 55). This is a Siluroid character. I have also described a similar state of things in *Gasterosteus*. The post-clavicle (op. cit., fig. 40, 58) is very slender; there are two very long brachials, the lower much the largest (op. cit., fig. 40, 56). Here is another *generalised* character, reminding the observer of the Crossopterygidæ — a sub-order of the Ganoids (see Huxley's 'Mem.,' p. 23); and the Woodcut (fig. 1 C) already described.

I now come to the Shoulder-bones of the typical Fish, namely, the higher genera of the Acanthopteri and the Pharyngognathi: all these, as a rule, conform to one pattern of growth, and may all be illustrated by the structures to be found in one of the least typical genera, for example, *Channa*. I shall afterwards give an illustration or two of gentle deviations from this typically ichthyic condition, and then return, by as short a route as possible, back to the Ganoid border.

ACANTHOPTERI TYPICI.

Fam. "OPHIOCEPHALIDÆ."

Example.—Channa orientalis, Schneider.

For a description of the "Ophiocephalidæ" generally, and of *Channa* in particular, I refer the reader to Dr. Günther's invaluable 'Catalogue of the Acanthopterygian Fishes in the British Museum,' vol. iii, pp. 468—483; they come next after the Grey Mullets (Mugilidæ). The Woodcut (fig. 6 D) shows the right moiety of the Shoulder-girdle, with its splints, as seen from the inside; and this drawing may serve as a *diagram* for what may be found in by far the greater number of the nobler Fishes, viz. the Percoids, Sciænoids, Scomberoids, Chæto-donts, Mugiloids, and the Labridæ. The post-temporal (fig. 6 D, p. t.) is bifurcate above; it overlaps the spatulate supra-clavicle (s. cl.), which in its turn overlaps the clavicle (cl.). The clavicle has an outer and an inner lamina in front, a broad upper part, and a feeble posterior plate, for articulation with the true Shoulder-bones. The upper post-clavicle (u. p. cl.) is an elegant, semi-oval, foliaceous bone, with a feebler, styloid, lower post-clavicle (l. p. cl.) articulated to its inside. The scapula (sc.) is an irregularly pentagonal plate, well ossified, and having an horizontal ovate fenestra (sc. f.); its "glenoid" margin receives the brachials (b.). The oblique synchondrosis between the scapula and coracoid (p. cr. cr.) is narrow, and the latter bone is well ossified; the præ-coracoid portion is oblong, and of considerable size; the coracoid proper joins the præ-coracoid by a very narrow isthmus; but this narrow part is supple-mented by the anterior and posterior "interclavicular alæ;" the hinder of these underprops the lowest brachial; they both turn inwards. Below, the coracoid becomes thick, and it ends in the concavity of the clavicle, at the top of its lower fourth. The brachials (b. 1—4) are four in number; they increase in size from above downwards, the upper being almost triangular, the rest short-oblong; the lowest has an inferior wing: and all of them are thick and well ossified, with but little intermediate notching.

Fam. "SCOMBERIDÆ."

Example 1.—*Zeus faber,* Linn.

Cuvier ('Règne Animal') must have had good reasons for placing this Fish amongst the Scomberoids; yet it is a most aberrant form, and so is the next example which I shall give, namely, the Opah (*Lampris*).

The post-temporal of the Dory (Plate I, fig. 14, p. t.) is closely articulated with the skull, as in *Lophius, Syngnathus,* &c.; it is a narrow dense bone, and articulates with the epiotic above, and with the pterotic and opisthotic below; two strong tubulated supra-temporals are strongly clamped to it in front. It has a deep condyloid cavity for the supra-clavicle below; and this latter bone (s. cl.) has an elegant trochlea at its top, for articulation with that cavity; its direction is inwards. The supra-clavicle is styloid below, and has three retral spines above, like the sub-marginal spines, above and below the body of the Fish ; these spines are separated by sharp notches. The clavicle (cl.), which is deeply sulcate at its outside above, for the supra-clavicle, is an extremely long bone, and withal very strong; it is bent on itself, at a few degrees more than a right angle, at the junction of its upper and middle third, and behind the bend there is a sharp spine, which looks upwards. Below this spine there is a triangular plate, which overlaps the post-clavicle (p. cl.) ; above the spine this dense bone is flat on the outside, smooth, and semi-cylindrical within. Below the bend the bone is curved gently backwards, and is divided by three deep sulci into three strong, smooth wings—an antero-internal, an antero-external, and a posterior ; the antero-internal, from its upper half, sends backwards a fourth plate, the innermost, which reaches only half way down. The three main wing-tracts are continued to the bottom of the bone, where it is tied to its fellow of the opposite side. The post-clavicle (p. cl.) is spatulate at the top ; then thick, strong, four-edged, and grooved deeply in front and behind ; it meets its fellow of the opposite side, at a great distance from the clavicle ; yet it is set on to the inside of that bone by much less than a right angle. This bone is like that of the Balistidæ, and so are many other parts of the skeleton of this strange-looking Fish ; and I am of opinion that this type is the nearest point of meeting of the Acanthopteri with the Plectognathi. The scapula (sc.) is typical, but its "fenestra" is finished in part by cartilage ; there is also a considerable tract of cartilage between it and the coracoid. The scapular part of the glenoid region receives the three upper brachials and part of the lowest (b. 1—4). The coracoid, deprived of its inter-clavicular alæ, would be an elegantly adze-shaped bone ; its præ-coracoid part (p. cr.) is a quadrant, with a cartilaginous selvedge along its rounded supero-anterior edge ; this edge and the front margin of the scapula are partly hidden by the posterior plate of the clavicle. The hinder and lower margins of the præ-coracoid are very thick ; where these thick edges meet, the body of the coracoid has been reduced to a small isthmus of cartilage ; but it gradually increases to an exquisitely rounded, delicate, subarcuate rod downwards. This rod is invested by a very dense, highly polished ectosteal sheath, which does not quite reach the base of the clavicle ; but the free cartilaginous end of the coracoid does gain the abdominal line. The nerve-foramen (cr. fo.) is seen where the body of the coracoid is most attenuated ; behind this passage the posterior inter-clavicular wing sends upwards a blunt spine ; this narrow ala only reaches half way down, and it is curved a little outwards. The anterior inter-clavicular wing is very large, and occupies two thirds of the front of the coracoid rod ; it is crenate, with notches of various sizes in front, lies a small distance from the posterior wing of the clavicle, and its junction with the lower edge of the præ-coracoid can be clearly seen above ; yet there was but one ossification for the whole coracoid originally, as far as I can make out. The whole of the coraco-scapular plate is gently convex on the outside. There are four brachials (b. 1—4) ; they increase in size, both as to length and breadth, from above downwards ; they have the hourglass-shaped outline, are very long, and are unossified at both ends.

Example 2.—Lampris guttatus, Retz., Cuv.

The skeleton of the Opah, to be seen both in the Hunterian and British Museums, is well worthy the study of the anatomist who would understand the relation of the subcutaneous splints to the endo-skeleton ; in it they are both developed in a very extraordinary manner.

The post-temporal is forked, and the supra-clavicle is a sub-triangular plate; the clavicle is of an enormous size, and is bent backwards much more than in the Dory (Plate I, fig. 14, cl.). There is a large ovato-oblong upper post-clavicle, and an extremely long lower post-clavicle; so that this Fish comes very near the spiny Globe-fishes in this respect (see Woodcut, fig. 4 C, u. p. cl., l. p. cl.). There is a very large, lanceolate membranous interspace between the concave posterior outline of the clavicle and the concave anterior outline of the coracoid. The scapula is semicircular, and has a rounded "notch" in front instead of the usual fenestra. The synchondrosis between the scapula and præ-coracoid is very narrow, and almost horizontal; and in the latter bone the distinction between the præ-coracoid and the coracoid is but slightly evident, for the inter-clavicular wings are of great extent, and the original cartilagious model has left but little mark in this expanded bone. The coracoid reaches to the basal line below; and it seems very probably to have had originally some assistance from an "inter-clavicular" ossicle; otherwise the periosteal layers of the ectosteal sheath of the coracoid have indeed run riot. The osseous substance of the true Shoulder-girdle is dense, but coarse; that of the splint system is extremely splintery, but these bones are stronger than those of the Balistidæ, just as these are stronger than those of *Diodon* and *Ostracion*.

If there are any Genera lying in a direct line between these most aberrant Scomberoids—the Dory and Opah—and the Plectognathi, a knowledge of their osseous structure would be extremely interesting: perhaps some *Semi-plectognath* may turn up.

Fam. "Percidæ."

Example.—Mullus barbatus, Linn.

The Shoulder-girdle of the Red Mullet differs in one important point from ordinary typical Acanthopterous Fishes, namely, in the presence of an additional fenestra to the scapula. The Woodcut (fig. 6 E) shows the left coraco-scapular plate from the outside, and magnified two diameters. The letters a. f. indicate the anterior fenestra; p. f., the posterior; p. sc., the præ-scapula; m. sc., the meso-scapula; and sc., the scapula proper, or post-scapula. The glenoid region (gl.) is principally scapular; the synchondrosis is moderate; the præ-coracoid (p. cr.) very broad; the moderately developed inter-clavicular wings of the coracoid (cr.) have an average size. I have not hitherto seen any other instance of the additional fenestra of this scapula in Osseous Fishes, but I have already described it in the Skate (Plate I, fig. 2); here, however, the anterior fenestra is *coraco-scapular;* that this makes no real difference will be seen from my next instance, namely, the Cod, in which the single fenestra belongs to both regions.

When we come to the Lacertilia, this triple condition of the scapula will be seen again; and it is very clearly indicated in certain Mammalia.

The Order Anacanthini is not very far removed from the Acanthopteri typici in the structure of their Shoulder-bones; but there are differences worth noticing. It was in observing the structure of the common Cod-fish that I first saw the relation of the true Shoulder-girdle to its splints, and also that the coracoid of this and of typical Fishes generally is essentially a double or forked ray—a view the truth of which can be easily demonstrated by a reference to the state of these parts in the Carp and its congeners.

Fam. "GADIDÆ."

Examples.—Morrhua vulgaris, Cuv.; *Morrhua æglefinus,* Cuv.; *Merlangus vulgaris,* Cuv.; *Merlucius vulgaris,* Cuv.

The shoulder-splints of the Cod, Whiting, and Hake are quite normal as to strength; but the stoutish post-clavicle is single. The knife-like supra-clavicle and the large clavicle of the Cod are well shown in Huxley and Hawkins's 'Atlas' (pl. xi, figs. 12 *a* and 12 *b*); it is seen in these figures how that the true Shoulder-plates (*b c*) are only half the length of the clavicles (*a*). In the Cod (*Morrhua vulgaris*), and still more in the Hake (*Merlucius vulgaris*), the post-branchial part is narrow, but thick; the antero-external lamina, especially in the Hake, lies quite externally, close under the skin of the Fish's side.

The posterior lamina of the clavicle is turned inwards, and only serves for the attachment of the scapula and præ-coracoid; it passes *outside* them (see 'Atlas,' fig. 12 *b*). In the Whiting (*Merlangus vulgaris*) the bones are similar to those in the Cod; they are very delicate and thin, but well ossified. In the Haddock (*Morrhua æglefinus*), however, the splint-bones are all extremely solid, approaching in this respect the "os petrosum" of the Mammalia. In this latter Fish the spine of the post-temporal is long and delicate, but the head of the bone is very massive; the supra-clavicle is a stout nail, with an oblique head; and the clavicle, stout throughout, is, in its lower half, a solid, thick spindle of bone. The post-clavicle, which is single and large in all the Gadidæ, is stoutest in the Haddock; in all the head is dilated and hooked. The scapula of the Gadidæ differs from that of the typical Fish, in having the fenestra (c. s. f.) common to it and the coracoid (see Plate II, fig. 15, c. s. f.); but the most important thing to be noticed is in the differentiation of the cartilage into three rays—a division first marked out in the Skate (Plate I, fig. 2), but more clearly to be seen in certain Lizards, *e. g.* the Iguana. This triple condition of the coracoid in the Cod-tribe is partly masked by periosteal growths, that fill up the angle of the "notch" between the meso-coracoid and the coracoid; and the lower part of the "fenestra," which belongs partly to the scapula, and originally extended downwards to the common point of union of the three rays of the coracoid. If the reader will hold the macerated coracoid of a Haddock up to the light, he will see the triangular præ-coracoid, the narrower meso-coracoid—broadest in front, and the long, delicate coracoid proper. Between these is to be seen the thin, intervening, *periosteal* spaces; the upper filling-up the pointed, lower part of the "fenestra;" the middle one in the almost right-angled space between the meso-coracoid and coracoid; and the large "posterior inter-clavicular wing," which rises up below the lowest brachial (Plate II, fig. 15, b. 4), and runs to the bottom of the rod in the Cod and the Haddock. In the Hake (*Merlucius*) the parts are all slenderer; the coracoid, especially, is extremely delicate (twice as long as in the other Gadidæ), and has its "wings" only half the length of the rod out of which they grow. The thick, stout brachials are somewhat hourglass-shaped; there are four of them, and they increase in size from above downwards.

The soft-finned Fishes (Malacopteri) that go to form Müller's Order Physostomi will bear considerable subdivision; yet it is easy to see that the Apodal types should form a Sub-order (see Owen's 'Lectures,' vol. ii, p. 48); but the Siluroids, which I have already treated of, ought certainly to make a Sub-order by themselves. Then, as far as my part of the skeleton is concerned, the Salmonoids, Cyprinoids, and Clupeoids, go together to form another group; at any rate, they most clearly foreshadow the Amphibia in the structure of their Shoulder-girdle. The plan of this Memoir, however, embracing, as it does, the Shoulder-bones of all the Vertebrata, does not allow me to linger amongst the Fishes, but only to catch up the chiefest modifications, so as to throw light upon these structures in the whole "Sub-kingdom."[1]

Fam. "MURÆNIDÆ."

Example.—Anguilla acutirostris, Yarrel.

My dissections of the Sharp-nosed Eel were made from very young specimens; the one whose Shoulder-plates are figured (Plate II, fig. 9) as magnified twenty diameters, measured three inches in length. There is no post-temporal; the post-clavicle also is absent; but the supra-clavicle (s. cl.) is a strong rod, slightly bent backwards, blunt above, pointed and flat below; both this bone and the clavicle are very solid, rounded bones for a Fish. The lower splint-bone (cl.) is like the one above it, but is twice as long and twice as thick; it is reduced to a rounded point above, where it is somewhat flattened, and it is pointed below; above the point there is a scooped space on the outside. Altogether, the clavicle of the Eel comes very near to that of the Blindworm (*Anguis*); it is very loosely connected with the true Shoulder-girdle moiety.

The inner element of the Eel's Shoulder is a flat four-sided plate with all the angles except the postero-inferior, produced into a more or less rounded process. It is of moderate thickness, but very flat on both sides; the bony scapula and coracoid have both appeared as semicircular ectosteal plates. The former (sc.) is placed between the ascending, long, anterior process of the cartilage and the shorter posterior lobe; it is like a saddle, and the unchanged cartilage simulates the neck and rump of the Horse. Antero-inferiorly there is an oval "fenestra" (sc. f.), with its narrow end backwards, and its broad end reaching the cartilage in front; the back of the saddle-shaped bone is sinuous. The coracoid (cr.) is much like the scapula, but broader, and it has no fenestra; there is a large "clavicular," a "glenoid," and a "synchondrosial" tract of soft cartilage. The glenoid region is at first concave, and then convex in outline; it is in relation with eight drumstick-shaped brachials (b. 1—8), which are small, and feebly ossified, being soft at their enlarged ends.

My first Abdominal Physostomous Fish belongs to a group which looks towards the *Lepidosteus*.

Fam. "ESOCIDÆ."

Example.—Esox lucius, Linn.

As the splint-bones of this Fish are, on the whole, typical, I shall confine myself to the true Shoulder-girdle. The specimen dissected and drawn (Plate II, figs. 10, 11) measured six inches in length, and the figures are magnified twelve diameters. Fig. 10 shows the left moiety

[1] The position of the *Gasterostei* with their *abdominal* "ventral" fins, is very doubtful. The ligament which binds the anterior extremity of their swim-bladder to the upper part of the alimentary canal is always perforated in an early stage.

from the outer or convex side; and fig. 11 is a section through the widest part, illustrating the convexo-concave character of the plate, and the manner in which it is becoming ossified. The general form is crescentic, but the upper and lower ends are dilated—the former in a rounded manner, and the latter, which is much less enlarged, is emarginate. The middle part of the cartilage is greatly expanded; in front in an evenly rounded manner, whilst the hinder margin is developed into two slightly separated lobes.

As there is, in my knowledge, no Fish with a fenestrate coracoid, I shall take the "fenestra" as a landmark. To the middle of the "fenestra," at least, and perhaps lower, all is referable to the scapula; and the osseous plate is essentially scapular, but the fenestra is *coraco-scapular*, as in the Codfish; and the scapular bony plate has trespassed on to the coracoid region. But the whole of the glenoid margin (gl.) is scapular, and below that region to some extent; here the bony substance began, and passed over the inner and outer side of the plate simultaneously. The glenoid region has four irregular notches, and there is a very arrested brachial series of rays articulating with that notched border. The whole brachial plate has the form of a triangle, nearly equilateral, with the apex downwards. From the base, one somewhat bent, drumstick-shaped ray (b. 1), with soft ends, has been perfectly cloven; but the next ray, which is shorter, is separated from the one below it by a long "notch," which is closed proximally. A feebler and shorter third ray, not severed from the second, comes next; this is severed from the rather large apical part by an *anterior* notch, closed by a considerable isthmus of cartilage behind. This band of cartilage is continued nearly all round the lowest and smallest ray (b. 4), which is triangular, and clamps the upper edge of the apical moiety.

The morphologist could not desire a more instructive stage than this; the process of cleavage, or dehiscence, takes place, as it were, before his eyes, and in obedience to a law which in one sense is unalterable, and, in another view, may be said to produce all the variety to be seen in the Vertebrate Endo-skeleton.

Fam. "SALMONIDÆ."

Example.—Salmo fario, Linn.

In Plate II, figs. 7 and 8, the Shoulder-girdle of a half-grown Trout are shown, magnified two diameters; fig. 7 shows the outside of the left moiety, and fig. 8 the inside. The splint bones are simple, fibrous plates; tender, and very inornate, as compared to what we see in the Acanthopteri. The post-temporal (p. t.) is strongly forked; the supra-clavicle (s. cl.) long and spatulate; the post-clavicles flat, thin, and, contrary to the rule, the lowest is much the largest. The clavicle (cl.) is strongly bent forwards on itself at the upper third; its post-branchial plate forms almost the whole of the bone, the outer part of which is parallel with the sides of the Fish, whilst the inner part, slightly concave, looks as much forwards as inwards. The posterior plate, therefore, must be looked for on the inner side (fig. 8); it is a very long balk or ridge of bone, and gives attachment to the anterior margin of the scapula. This latter bone (sc.) is imperfect in front, there being a large headland of soft cartilage; it has in it a smallish "fenestra" (sc. f.); the whole region is subquadrate. Between the scapula and the coracoid proper there is a considerable tract of cartilage (fig. 7, sc. cr.); the coracoid (cr.) is thick, trihedral above, elegantly arcuate, with the convexity backwards, and it has a long sub-brachial process; both the scapula and the coracoid lie in the same plane, and the soft end of the coracoid reaches nearer the abdominal line than the clavicle. But *inside* the junction of the scapula and coracoid there is a mass of cartilage, which sends a long and stoutish crus forwards and upwards, so as to be attached to the inner ridge of the clavicle, near its middle (fig. 8). This bar is ossified, save at its ends, in the same manner as the scapula and coracoid, namely, by "ectostosis;" it is the præ-coracoid, which in nearly all the examples hitherto given has been ossified continuously with the coracoid proper. This element figures greatly in the Amphibia, as an ectosteal bone; but never afterwards, as far as I know, as it is soon subjected to morphological degradation; and although it often reappears, it is always as a late-ossifying *endosteal* bar. If we compare the brachials of the Trout with those of the Pike, we shall see that Nature has "changed hands," and that these rays, which are like small drumsticks, increase in size from above downwards (see figs. 7 and 8, b. 1—4); they are soft at each end, and the lowermost has a small periosteal wing.

I shall omit the Cyprinidæ, for although they differ from the Salmonidæ so much in the character of their bones, which are as remarkable for density and strength as the others are for extreme thinness and friability, yet, morphologically, there is very little difference between them.

Fam. "CLUPEIDÆ."

Example.—Clupea harengus, Linn.

Here we have the same kind of Shoulder-girdle as in the two last-mentioned families; but there are some curious differences, and there is a gentle but evident descent in these Fishes towards the true Ganoids. All through its skeleton, the Herring shows how little it has been subjected to the severe numerical laws that affect the typical Fish; yet it is most instructive, that what is excessive for an ichthyic type, is the true number for some higher type. This is well seen in the face, for few Fishes possess a malar or jugal; but the Herring has this bone, and a "septo-maxillary"[1] as well: this condition is the rule in the true Reptilia. So for *vertical* division of the arm-plate; it occurs in the Ganoids, even amongst the recent ones, as *Polypterus* and *Calamoichthys;* but the Herring is the only Teleostean in which I have discovered this second series. The splint-bones are fibrous, but tough and strong; they are smooth, diaphanous, concentrically marked, and correspond exactly to the *overlapped* part of the "cycloid" scales of the same Fish. The post-temporal (fig. 6, p. t.) has a large thin body, with a long bony mucous tube on it; its spurs are long and arcuate; below, it overlaps the supra-clavicle. This latter bone (s. cl.) is long, has a strong principal part, broader at the top than below; behind the base of the overlapping supra-temporal it gives off a semicircular plate, the exact counterpart of the hidden portion of the ordinary cycloid scales of this Fish. The clavicle (cl.) is much like that of the Trout, for the antero-internal wing looks inwards and forwards; the antero-external plate lies under the skin of the Fish's side. The posterior lamina of the clavicle is only developed below, for the true Shoulder-girdle has, here, the same low position as in the Trout. The lower part of the clavicle is hooked backwards, as in the Opah-fish; and above this part it

[1] This term is new to science, and is now being used by me in a paper on the "Osteology of the Kagu" (*Rhinochetus*); I consider it to be the fore-runner of the so-called "turbinal" of the Lizard—the "pre-vomer" of my former papers.

has several enlargements, both before and behind; one of these, in front, is a "cycloidal" plate growing off from the body of the bone, and attached by a broad isthmus. The post-clavicles (Plate II, fig. 6, p. cl.) are extremely interesting, for there is an additional piece; and, whilst they retain their normal relations with the supra-clavicle, they yet have a new relation to the clavicle itself,—lying on its *outside.*

The first (p. cl. 1) is a long lozenge, lying within the supra-clavicle at the top; the next (p. cl. 2) is spatulate, and is overlapped in the same way by the one above; it also overlaps the top of the third (p. cl. 3), which is long, styloid, *f*-shaped, and reaches the abdominal line. These three post-clavicles answer to a subdivision of the subcutaneous part of the second infero-lateral plate of *Callichthys* (Plate I, fig. 9, p. cl.); they have no representative in *Gasterosteus leiurus* (see Woodcut, fig. 5 A) for the second lateral line-bone (l. l. 2) is small in that Fish, and the rest of that second cincture is aborted by the huge Shoulder-plates. The abnormal position of the post-clavicles in the Herring seems to arise from their having taken the cue of their growth from the supra-clavicle only, thus losing their relation to the clavicle, which, indeed, grows in a very wild way sometimes; and I believe that variations *in overlapping* in these splint-bones are merely like variations in the growth of *sutural teeth.*

The bend backwards in the clavicle is very low down; and the scapula is placed below the bend (Plate II, fig. 4, cl. sc.); whilst the coracoid is placed face to face against the hollow inside of the lower part of the great splint, and reaches quite as low, namely, to the abdominal line.

There is but little cartilage left between the coracoid and scapula (fig. 5, sc. cr.), and their line of union is very sinuous; the front margin of the fenestrate scapula is soft, and so is the space between the styloid præ-coracoid, and the coracoid (fig. 4, p. cr. cr.). The bones themselves are very strong and ivory-like; but the coracoid is quite a sieve, all but the margin being pierced throughout. Two of these perforations, in the lower part of the bone, tend to divide it into a præ-, meso-, and post-coracoid; but the fission is very irregular, and its dehiscing force has been scattered all over the bone. The supero-posterior part of the coracoid is strongly developed into sub-brachial snags. The brachial plate is well developed, its smallest end upwards, as in the Trout; it is divided both horizontally and vertically; horizontally into five bars, and vertically into two series, the front rays being much larger than those behind, which are little rounded masses of bone. This subdivision of the arm-bones is what obtains in *Polypterus;* it is new to me as occurring in a Teleostean, and I believe, in this respect, new to Ichthyotomy; at any rate, it is another explanation of the reason why the genus *Amia* should have such evident Clupeoid relationships.

AMPHIBIA.

GENERAL REMARKS.

In passing from the Fish-class to the Amphibians, the *Proteus* meets us at the very outset with a grade of development very little above what is to be found in the Fishes. Indeed, the whole group of Amphibians are so simple in their early embryonic development, that some anatomists propose to class them, together with the Fishes, as one group—the "Ichthyopsida."

And yet the paternity of this Sub-reptilian group can be charged upon no particular Order of Fishes; their nearest relatives are to be found amongst the generalised types, such as the Plagiostomes, the Sturgeons, and *Lepidosiren.*

They all agree with the two latter types, and with Osseous Fishes generally, in having only (as a rule) two or three vertebræ that can fairly be called *cervical;* for the apex of the supra-scapula in the Frog, as well as in *Proteus,* is, in its first appearance, in relation with the second "intercentrum," or between the second and third vertebræ, exactly as in the Cod-fish.

The most snake-like of the Amphibians, namely the Cæcilians, do not possess such accessory parts of the skeleton as limbs, or even limb-roots, at least as far as my opportunities for dissection have gone. My subject was the *Epicrium glutinosum,* from Ceylon.[1] In all those Amphibians in which metamorphosis does not affect the tail (Amphibia Urodela) the ossific process is much more arrested than in the Anoura; but in none of them is there any correlation of dermal bones to the Shoulder-girdle; on the skull there is such a coexistence of both species of bone; but not to the same extent as has been described; the supposed splints of the lower jaw being, in reality, "ectostoses."

In the Urodela by far the greater part of the Shoulder-girdle, and all the Sternum (which is developed in most of the genera), continues totally unossified throughout life, whilst the "endostosis" which is set up within each ectosteal sheath is not quite coextensive with the outer layer of bone, and can only be seen in sections. Moreover, the "ectostoses" are arrested, so that they only cover part of the territories to which they belong; and in certain genera only one or two of these bony patches are developed.

"Amphibia urodela."

A. *With one Ossification in each moiety of the Shoulder-girdle.*

Example 1.—*Proteus anguinus,* Laurenti.

My specimen of *Proteus*[2] measures eight and a half inches from end to end; and the figures

[1] The gift of Dr. Günther.

[2] This, with two fine Axolotls, and several other valuable specimens, I have received from Mr. Edmund Christy; they belonged originally to his late lamented brother, Mr. Henry Christy.

I have made from dissection of its Shoulder-girdle (Plate III, fig. 1, and Plate IV, fig. 1) are magnified four diameters. The girdle is incomplete both above and below; above, each "supra-scapula" (s. sc.) is a line below the spines of the second and third vertebræ; below, the "epi-coracoids" (e. cr.) are a line apart. The cartilaginous supra-scapula is somewhat triangular in shape, but runs into a bilobate form through the concavity of the upper margin and the roundness of its free angles; the front angle projects most. The scapula (sc.) is a very delicate, flattened, phalangoid ray; it is a shaft-bone, so arrested at both ends as to make the supra-scapula appear larger than it really is, whilst, below, the glenoid region is, like all the rest of the half-girdle, entirely unossified.

The whole structure on each side is continuous; but two clefts appear, and are arrested; one, rather small, in the fundus of the glenoid cup (gl.), closed at both ends, and pear-shaped; whilst the other is a large notch, almost separating the præ-coracoid from the coraco-epi-coracoid plate (p. cr., cr., e. cr.). The smaller, anterior end of the glenoid cleft answers to the generally distinct nerve-passage, so well known in the coracoids of the Oviparous Vertebrata.

This is one of the most interesting points in the morphology of the Limb-girdles: we have seen the scapula completely cloven from the coracoid, and the middle brachials wedged in between them in *Cottus;* and now the first and lowest Amphibian has these two main regions to a considerable extent separated by a cleft; another instance will immediately be shown, and then we see no more of this cleft until we are some way into the Class of Birds, where, with the exception of the typical Ostriches, it is always present and always perfect. Once out of the Bird-Class, however, and we see it no more except in the Mole; yet in the Bird-Class we always have its pelvic counterpart in the oval fenestra in the fundus of the "acetabulum," partially separating the "ilium" from the "ischium"—the two rays which, in the pelvis, represent the scapula and the coracoid.

The cleft between the præ-coracoid and the main coracoid is imperfect proximally; it is a notch, which to a great extent separates the former knife-shaped flap of cartilage (p. cr.) from the latter, which is a large, oval, convexo-concave plate, the extensive, free, thin, lower margin of which does not reach the mid-line of the body; the right and left moieties are a line apart; this distal margin of the coracoid is the "epi-coracoid" (e. cr.). Below the thickened margin of the glenoid cavity the coracoid has a crescentic notch; this is opposite the anterior cleft, so that there is here a rather narrow waist to the cartilaginous plate, an isthmus scarcely two lines across (Plate IV, fig. 1, p. cr., cr.). No cartilage is developed in the *inner* layer of the lower part of the thoracic walls, such as exists in most of the Urodela; that is to say, there is no Sternum (Plate III, fig. 1).

Example 2.—*Menobranchus lateralis*, Harlan.

My figures of the Shoulder-girdle of this South-American Amphibian have been made from Professor Hyrtl's *dry* skeleton[1] of an adult male, and here I have no Sternum to speak of, although I am not certain of its non-existence; the figures are magnified two diameters

[1] I have made free use of the invaluable specimens in the Museum of the Royal College of Surgeons, which were purchased of Professor Hyrtl in 1862; one splendid case is full of Anoura, the other contains the Urodela (including the Cæcilians), and also the Reptilian *Chirotes*.

(Plate IV, figs. 2 and 3). Here the supra-scapula (s. sc.) is somewhat fan-shaped, with the anterior angle sharp, whilst the posterior angle is rounded. The scapula (sc.) is relatively broader than in *Proteus*, but is similarly arrested at both ends. I can see no glenoid fenestra in this preparation, and the nerve-passage is large and distinct, about a line behind the end of the great coracoid notch.

The præ-coracoid (p. cr.) is relatively somewhat longer than in the Proteus, and the epi-coracoid (e. cr.) is rather notched in the middle of its free margin.

Example 3.—*Menopoma alleghaniensis*, Harlan.

My figure of the Shoulder-girdle and Sternum of this North-American Amphibian is partly from Professor Hyrtl's dry preparation of a young male, and is partly also copied from plate v, fig. 2, of his valuable work on *Cryptobranchus*; it is shown as magnified two diameters. The supra-scapula (Plate III, fig. 4, s. sc.), is of a less elegant shape than in the *Menobranchus*, and the scapula (sc.) is more ossified; partly affecting the glenoid cavity, above. I am not aware if there be a glenoid fenestra; but at any rate the nerve-passage is quite distinct. The wholly unossified præ-coracoid and coraco-epicoracoid differ from their counterparts in the last species by their rounded contour, and the former flap (p. cr.) is relatively shorter and broader; the free margin of the epi-coracoid (e. cr.) is sinuous.

This is my first instance of a Sternum (st.), but as the next two instances will show that part better I shall describe them more at length. This figure (from Hyrtl), shows, however, the thick inner lips of the coracoid grooves, the grooves themselves, the scooped inner face of the Sternum in relation with the pericardium in the fresh specimen, and the emarginate, abrupt, posterior margin, with no meso-xiphisternal rudiment, such as we shall soon have to describe; the whole of this *protosternum* is the counterpart of the "manubrium" or "præ-sternum" of Man and the other Mammals. This little cartilage is primarily double, and belongs to the first dorsal vertebra, and perhaps also to the last cervical; and the non-development of the greater part of each costal arch, laterally, does not altogether prevent the out-cropping of a portion of the inverted *keystone*, which in the air-breathing Vertebrates is so constant a correlate of the Shoulder-girdle. The visceral laminæ as they approach may be thick or thin, according to what may be developed in them; but when the Shoulder-girdle and Sternum are coexistent in the same somatome, the latter is on the *inside* of the former, and, as it develops, its perichondrium will be found to run insensibly into the fibrous layer which lines the thorax, and also, most intimately, into the pericardium.

Example 4.—*Cryptobranchus japonicus*, Bechstein.

My figures of *Cryptobranchus* (Plate III, figs. 2 and 3) are taken from Professor Hyrtl's work (plate v, figs. 1 and 3); they are of the natural size. By comparing figs. 2 and 4 it will be seen how much the corresponding structures are alike in *Cryptobranchus* and *Menopoma*; the supra-scapula (s. sc.) is not so broad relatively in the former as in the latter; but the præ-coracoid (p. cr.) of *Cryptobranchus* is much the broadest, and is of an elegant elliptical shape; the cleft dividing it from the coracoid (cr.) is also more developed than in *Menopoma*, as is seen by the position of the nerve-passage. The epicoracoid region (e. cr.) is also less produced anteriorly.

In fig. 2 the glenoid fenestra is not seen—it lies in shade, but it can be seen in fig. 3; it is quadrilobate. The Sternum (st.) is two-thirds the size of the coraco-epicoracoid plate, and is very unsymmetrical; this arises from its relation to the overlapping epicoracoid. In the figure it is shown as drawn away from these flaps, but they, in certain positions of the living creature, reach to the oblique, thick ridges on the inside of the sternum; anterior to these ridges the unequal, thin, sinuous, lower coracoid lips are seen, which are out-growths of the primordial part of the Sternum, and which *underlie* the epicoracoids. The antero-lateral margins are notched (sinuously) twice; the posterior margin is deeply bilobate, and near the emargination there is a foramen—not an uncommon thing in the Sternum of the Urodelous Amphibians.

Example 5.—*Siredon pisciformis*, Shaw.[1]

The Axolotl's Shoulder-girdle and Sternum are shown in Plate VIII, fig. 1, three times the natural size; they are from fresh dissections, and are shown as somewhat outspread for the sake of diagrammatical accuracy. The fan-shaped supra-scapula (s. sc.) has a constriction below, showing the commencement of the true scapular region, left untouched by the arrested shaft-bone. The scapula (sc.) is oblong, with slightly sinuous sides, flat, and rather dilated below, not reaching quite to the middle of the glenoid excavation, which is triangular and thick-lipped: it is not fenestrate within, but is carved out of thick cartilage. There are two nerve-passages, a line apart, on the left side, showing that they are not a very accurate landmark, but useful, nevertheless. The præ-coracoid (p. cr.) is narrow, oblong, short, and slightly emarginate at its free end; the notch is cut out in a rounded manner, and its lower boundary, or outline of the epicoracoid (e. cr.), is wavy. For the rest, the main coracoid lamina is large, oblong, squarish behind, and rounded in front; its posterior angle is rather acute and produced, like what is seen in all the higher Ovipara. The left moiety underlies the right, and, in an undisturbed state, the large free edges of the Sternum underlie both; the epicoracoid edges abutting against the thick inner coracoid lips—the earliest part of the Sternum. This is the most symmetrical Sternum to be seen amongst the Urodela, but it is emarginate behind, and only represents the "manubrium." The decussating lines, showing where the great pectoral muscles crossed each other, are well seen; but there is no ridge for the *recti abdominis*—the Sternum is concave in this part, at the mid-line. The heart lies on the Sternum as on a shallow dish, and the connective fibres forming the pleural lining of the thorax, and those that form the pericardium, and the perichondrial investment of the inner face of the Sternum, are badly differentiated.

B. *With two Ossifications in each moiety of the Shoulder-girdle.*

Example 1.—*Siren lacertina*, Linn.

My figure of the right moiety of the Shoulder-girdle of the Siren (Plate III, fig. 5) is shown,

[1] The Axolotl, as I have learned since the above was written, is merely a large arrested *larva* of the American Salamander (*Amblystoma*): only a minority of individual Axolotls undergo metamorphosis.

as magnified two diameters, from Professor Hyrtl's dry preparation of an adult female from Carolina; but as the cartilages were somewhat spoiled by drying, I have finished this figure from the woodcut made from one of Sir Charles Bell's beautiful sketches (Fourth Bridgewater Treatise, page 68). The supra-scapula (s. sc.) is rather small and elegantly fan-shaped; the scapula (sc.) is a phalangoid shaft of bone reaching up well above, but, although broad, deficient below. The præ-coracoid (p. cr.) is knife-shaped, and the main coracoid more pointed at the ends than is usual. The nerve-passage is well shown, and the glenoid region is unossified, neither reached by the scapula above nor by the new bone, the coracoid, behind and below.

The coracoid shaft-bone (cr.) only covers half its own region, and is semi-oval, and thick at its concave, free, upper margin; its lower edge defines the epicoracoid (e. cr.) region behind. No Sternum is to be seen in Hyrtl's preparation, although I should suppose that it might be found in the fresh specimen.

Example 2.—*Amphiuma didactylum,* Cuv.

In this Amphibian I have been enabled to get a fuller conception of the Shoulder-girdle by referring to Hyrtl's work (plate v, fig. 4) as well as to his dry preparation of the parts. My figure (Plate IV, fig. 4) represents the inside of the right moiety, magnified four diameters. There is no Sternum to be found in the preparation, and I question very much whether it could be seen in the fresh state. This I infer on account of the very small relative size of the parts, and their persistent separation from each other on the sides of the thorax. The supra-scapula (s. sc.) is small and sub-triangular; the scapula (sc.), a somewhat curved and rather flattened ray, ossified as a shaft; whilst the rest of the structure is an irregularly bilobed convexo-concave plate. The præ-coracoid (p. cr.) is only slightly cloven from the other part by a triangular notch; there is a relatively large, squarish, bony coracoid (cr.) entirely insulated by cartilage, even along the glenoid margin, and towards the base of the scapula: all the epicoracoid (e. cr.) continues soft.

c. *With three Ossifications in each moiety of the Shoulder-girdle.*

Example 1.—*Phænerobranchus mexicanus,* Wagler.

The right moiety of the Shoulder-girdle of this Mexican Amphibian, is drawn from the skeleton of an adult female in the *Hyrtl Collection* (Hunterian Museum); it is magnified three diameters (Plate III, fig. 6). Here, again, I miss the Sternum, which must have existed in the fresh state; but I am glad of what I have found, namely an additional instance, besides that of the Newts and Salamanders, in which the three main regions of the Shoulder-girdle are to some extent ossified. In mere outline, this structure is like that of the Axolotl, but the præ-coracoid (p. cr.) is rather less, and diverges more; the scapular shaft (sc.) has ascended higher and descended lower, and has met and to some degree coalesced with a small, square, proximal præ-coracoid (p. cr.), and with a much larger, and very irregular coracoid (cr.) The large nerve-passage is seen to be in the suture between the præ-coracoid and the coracoid.

Example 2.—*Lissotriton punctatus*, Latreille.

I am able to give several stages of the Common Smooth Newt; the youngest of these was five and a half lines in length, and an external view of the left moiety of the Shoulder-girdle of this larva is shown in Plate III, fig. 7, magnified forty diameters.

Every essential part of the Shoulder-girdle is to be seen in this early stage, which represents the permanent condition of the *Proteus*; for the Sternum is not distinguishable in the delicate blastema forming the lower edges of the ventral laminæ.

The supra-scapula (s. sc.) is fan-shaped, and the handle-like part passes insensibly into the narrow scapula (sc.) which is already ensheathed by a delicate, corrugated ectosteal layer. The cartilage-cells of the scapular region are evidently entirely unaffected at present by the bony film which invests them. The rest of this plate of frail, young cartilage, is free from bony investment; the nerve-passage is very clearly displayed; and the coracoid notch is large and semicircular; the præ-coracoid (p. cr.) is a mere bud; and the epicoracoid (e. cr.) is a sickle-shaped bar. The glenoid cavity is a large wavy-sided triangle; and the proximal part of the humerus, the bony shaft of which has appeared, is seen in its place.

In another specimen of *Lissotriton punctatus*, nearly twice the length of the last, (ten lines), and the figures of which are magnified thirty diameters, great changes of form have taken place, and the Sternum is to be seen. The characteristic height of the supra-scapula (Plate III, fig. 8, s. sc.) is now shown; and the sheathing by a thin corrugated bony plate of three-fourths of the scapular region (sc.) The budding præ-coracoid (p. cr.) has become longer, but is still relatively short and narrow; the glenoid cavity (gl.) has acquired more perfect lips. The epicoracoid region (e. cr.) has spread in all directions, and is fast approaching the mid-line below; the notch has become narrow, and the nerve-passage has a large space of cartilage between it and the notch: no bone has appeared, except that which enrings the scapula.

The Sternum (Plate III, fig. 8, st.) can now be seen, but its cells are much younger than those which form the mass of the Shoulder-plate; and the left margin is merely a somewhat consistent band of granular blastema. The form is that of an equilateral triangle, but the base behind is produced, and not notched as in the Axolotl. I have not been able to find a primordial fissure along the mid-line of the Sternum in any Urodelous Amphibian; but in all the true Salamanders, even in the adult, the anterior margin is obliquely split for some distance. It is quite probable that the great priority of development of the moieties of the Shoulder-girdle, their huge relative size, and the great extent to which they overlap, may bias the growth of the tardier, and feebler, correlated sternal plate. I shall, without going out of my way, subsequently show some clear instances of unsymmetry in the right and left halves of the Sternum in the Warm-blooded Classes; and it is quite possible, and even probable, that one half of the very primordial Sternum of a Salamander may get the start of and overreach the other.

The next stage is that of a *Lissotriton punctatus* one inch and eight lines in length; the figure (Plate III, fig. 13), shows the inside of the right moiety of the Shoulder-plate; part of the left moiety; and the Sternum, magnified twelve diameters. The parts are drawn from each other, for they are very loosely attached, but the epicoracoids naturally lie in the sternal grooves, and overlap each other.

The supra-scapula (s. sc.) is a very regular oblong, save that the upper margin of the bony scapula (sc.) ascends as it passes backwards; below, it is wedged between the arrested præ-coracoid and coracoid shafts. Only the root of the now very broad, spatulate præ-coracoid (p. cr.) is ossified, and the nerve-passage lies in the proximal part of the suture which separates it from the coracoid; this latter bone is oblongo-lunate, and nearly reaches to the glenoid cavity (gl.). The extensive epicoracoid region (e. cr.) is much broader than in the last stage, and the Sternum (st.) shows the extension backwards of the posterior angles, the flappy condition of the margins (lower coracoid lips), the concavity for the pericardium, the oblique fissure separating the right margin from the rest of the Sternum, and which appears to be the primordial divisional line, and the evident xiphoid process. In Plate III, fig. 10, I have given the upper view of the Sternum of an adult, magnified twelve diameters, showing a very short xiphisternum, a very irregular condition of both upper and lower coracoid lips, and especially a remarkable chink, which would, if carried on, separate the Sternum in precisely the same way as it seems to be primarily divided in fig. 8. Fig. 11 is the under view of that of another adult, magnified twelve diameters, and showing a longer xiphisternum, with a strong keel that separates the *recti abdominis;* a thick mass between the oblique bevelling for the *pectorals;* the lower coracoid lips; and a deep oblique chink, which may indicate the primary separation between a small *right* and a large *left* moiety. The Sternum of another adult (Plate III, fig. 12, st.), which with the rest of the figure is magnified eight diameters, shows a still longer xiphoid process, and still more produced posterior angles; but the anterior chink is less demonstrable. In this last stage the supra-scapula (s. sc.) is relatively less oblong than the last, having a much more convex front margin, and being less deep. The scapula (sc.) is much broader, because of the *periosteal* filling in of the acute angle between it and the præ-coracoid (p. cr.). Here the præ-coracoid is narrower in front, and the epicoracoid (e. cr.) is broader. The three bones have coalesced, and the coracoid (cr.) has ossified most of the glenoid region. This figure shows to what an extent the epicoracoids can overlap each other in this group, where they attain their most exorbitant dimensions.

Example 3.—*Triton cristatus,* Laurenti.

For comparison with the last instance I give the parts of the Shoulder in the Warty Newt (Plate IV, figs. 12—15; figs. 12 and 13 magnified six, and figs. 14 and 15 nine diameters). The supra-scapula (s. sc.) of this large old male has the form which is found in the half-grown *Lissotriton* (Plate III, fig. 13), being very deep, and oblong in shape. The scapula (sc.) is very low and wide, and is almost anchylosed to the other bones; the deep rounded corner between it and the præ-coracoid (p. cr.) is filled in by periosteal growths. Part of the suture between the latter bone and the coracoid (cr.) is seen in front of the nerve-passage. The coracoid has reached still further into the extensive epicoracoid region (e. cr.) than in *Lissotriton;* and both this and the free part of the præ-coracoid answer very exactly to the corresponding parts in the half-grown Smooth Newt. Plate IV, fig. 12 well shows the liberal growth of the primordial skeletal substance, so ready to be metamorphosed in the Vertebrata generally, and yet so proof against metamorphosis over such large areas in these larva-like creatures. The Sternum (st.) of the Warty Newt is much like that of the smooth kind; but the anterior oblique fissure is on the other side, as though the *left* side had been the smallest. There are several holes through the cartilage, like the one in the Sternum of the Gigantic Salamander; and fig. 14 shows a double oblique bevelling for the *pectorals;* also a keel, the prototype of the great "entosternum" of the Bird. But the keel for the *recti abdominis* is the largest, and makes the short xiphisternum to be trihedral. The inner part of the Sternum is shown in fig. 15; it is bounded by the coracoid grooves in front, and by the concavity for the heart behind. Here I may refer to a section of these parts in the Smooth Newt, which throws light upon the same structures in the Amphibia Urodela generally. Plate III, fig. 14, shows the lower part of the thorax of an adult *Lissotriton* in a vertically transverse section and as magnified fifty diameters. The lower edge of the epicoracoids (e. cr.) are seen to rest on the shallow coracoid groove; the Sternum is seen to be somewhat concave at the mid-region, and thick submesially. This thick part indicates the place of the first deposit of cartilage, and is persistently, as it was originally, *inside* the lower lips of the Shoulder-girdle. The *pectorals* (p. m.) are seen with the tendinous raphe uniting them in the middle; whilst the cutis vera (c. v.) and the cuticle (c. t.) complete the cincture.

Example 4.—*Salamandra maculosa,* Laurenti.

My other instance of this group is the Common Salamander, and, thanks to Mr. Tegetmeir, I am able to give dissections of four individuals, of different ages. The youngest specimen was one inch seven lines in length; and the figures of its Shoulder-girdle (Plate IV, figs. 5 and 6) are magnified twelve diameters. The supra-scapula (s. sc.) is fan-shaped, and has its anterior angle notched; the scapula (sc.) is the only part ossified (this condition agrees with my first group); and it is much like, although less slender than, the scapula of the *Proteus.* The triangular coracoid cleft is not deep; and the broad præ-coracoid (p. cr.) is somewhat rounded at its free end: the glenoid cavity (gl.) is deep, acute anteriorly, and sharply lipped; in front of it is the very constant foramen. The rest of the plate of cartilage is oval and very large (fig. 6, cr., e. cr.), and overlaps its fellow to a very great extent. The Sternum (st.) is relatively smaller than in the Newt; its cells are younger than those of the Shoulder-plates; and in this stage the xiphoid process has not appeared. The flap on the right side is of more delicate tissue than the rest, and altogether appears to be of an independent growth; the flap on the other side—"left lower coracoid lip" is pointed and projecting, anteriorly. The muscular grooves are well seen crossing each other, and dividing the whole Sternum into four lozenge-shaped territories. The next stage is seen in fig. 7; it is the left moiety of the Shoulder-plate of one nearly adult, magnified five diameters: the main thing to be noticed in this specimen is, besides the relative stoutness, the advent of two new bones—the præ-coracoid (p. cr.) and the coracoid (cr.). The nerve-foramen is at the front of the suture between these two bones; altogether their development is very much like what we have seen in the Newt. In Plate IV, fig. 9, the whole Shoulder-girdle and Sternum of this specimen are seen from below; this figure shows the rounded præ-coracoid and epicoracoid flaps (p. cr., e. cr.); the overlapping of the latter; and the triangular Sternum (st.) with its foot-shaped xiphoid process. The lower coracoid lip of the right side is seen to be very large, and to be separated for one fourth its length by a clean-cut fissure from the rest of the Sternum: I may remark, that although I found no essential difference in the Sternum of the individuals dissected yet no two were alike in minor points.

In Plate IV, figs. 8 and 10, the parts of an old specimen are given, magnified four diameters; fig. 8 showing the left and part of the right Shoulder-plate, whilst the same parts are seen from behind in fig. 10. The former figure shows the complete fusion of all the bones, and the more pointed præ-coracoid (p. cr.); and the latter displays the *acetabuliform* glenoid cavity, and the thickness of the plate in its various regions; they both show what is worthy of remark, namely, that whilst in those shown in figs. 6 and 9 the left epicoracoid lay beneath the right, the right underlay the left in this aged individual.

In remarking upon fig. 8, besides the rich development of solid cartilage, let us notice that the angle between the scapula and præ-coracoid (sc., p.cr.) is not filled in by perichondrial bone. Plate IV, fig. 11, shows a section of the Sternum from side to side, and magnified ten diameters; it is much thinner than in the Newts, and is invested with a loose perichondrium passing insensibly into the *pericardium*. The letters st. are placed where the heart lay; the right side of the figure being the cutaneous surface.

"Amphibia Anoura."

Were it not for the Caducibranchiate Urodela—the Salamandrinæ, the gap between the Urodelous and Anourous types of Amphibians would be a large one; in reality it is not so narrow as might be supposed, for the difference between the two is wellnigh equal to that which is found between the *Heterocercal* and *Homocercal* Fishes; and like that which we have at last come to see between the *Archæopteryx* and the typical Bird. Besides the rapid absorption and modification of the large series of caudal vertebræ in the Anoura, we have a sudden and rather surprising development of the limbs; and it is not to be passed over without remark that, as *quadrupeds*,—although the "heavy-gaited Toad lies in" your "way," sluggish and languid, yet the highest type—the Frog, a *Locust* among the Vertebrates, has no compeer, gymnastically, until we come to the Kangaroo and the Beaver; and, although ichthyic in his essential nature, in activity he is at once a rival to both these athletes.

Consonant with the sudden activity of the Anourans we have remarkable changes in the structure of the Limb-girdles, and also of the Sternum; but the ribs are still abortive, and a large space exists in the side-walls of the thorax, unguarded by bone or cartilage (a correlation this, beautiful enough, with the extreme fecundity of these creatures), whilst in apposition with the huge, elastic, mobile Shoulder-girdle, a considerable Sternum crops out in the lower part of the thoracico-abdominal walls. In the Anoura a higher degree of segmentation is combined with a fuller ossification; and one new bony element, the "supra-scapula," developed by two kinds of *ostosis*, appears in every known species.

In all the known Urodela the *endosteal* deposits are entirely ruled by the much earlier and more potent ectosteal sheath; in the Anoura this state of things is rare, (for instance, in *Pelobates*); but as a rule the two processes are independent of each other: the two deposits of bony matter often continue distinct throughout life. The Anoura cannot trace their descent from one ichthyic fatherhood; for in them is combined the histological and morphological characters of the Plagiostomous Shark and Ray on one hand, and the Sturgeon and the ordinary Osseous Fishes on the other: like the Ray and Shark, however, as far as the Shoulder-girdle is concerned, they have borrowed no *parosteal* growth from the skin and its infoldings.

The order in which my instances are described does not assume to be "systematic," in a zoological sense. It will, however, harmonize unconsciously to a great extent with what is really natural. The fifth Plate, which shows the development of the Shoulder and Sternum in the common Toad and Frog, from my own dissection, may be passed over until the adult, or, as in some cases, the half-adult forms (shown in Plates VI and VII) have been described.[1]

A. *With no "Omo-sternum."*

A 1. With no cleaving of the Shoulder-plate.

Example.—Microps oxyrhynchus, Fitzinger.

Plate VII, fig. 11, shows the Shoulder-girdle of a young female of this minute Brazilian Frog, seen in an antero-inferior aspect, and magnified four diameters.

In this lowest Anouran the Shoulder-girdle, but for its three pairs of bony sheaths, would answer very accurately to that of a young Shark (*e.g. Galeus*), before coalescence of the two halves below. In this, as in all the Anourans (and as we shall see in all the Reptiles), there is no real transverse fission of the cartilaginous bars, although the flexion of the "supra-scapula" on the scapula (s.sc., sc.) is very considerable; for the bony deposit stops suddenly, and the intervening cells of cartilage become very much flattened: yet no connective fibre is intruded. The supra-scapula of *Microps* (Plate VII, fig. 11, s. sc.) is like the blade, and the scapula (sc.) the handle of a pruning-knife; the convex edge of the supra-scapula is only partially ossified by endostosis, and the outer bony plate covers about three fourths of the surface. A narrow synchondrosis bounds the scapula, both above and below, and the lower of these is continuous with the cartilage of the glenoid cavity (gl). Like the scapula, the coracoid (cr.) is a phalangoid ray, somewhat crescentically curved, and bounded below a narrow lunate band of soft cartilage. Save that the supra-scapula has in this case its own shaft-bone, this little Anouran has precisely such a simple Shoulder-girdle as the Dinornis,[2] Emu, Rhea, Cassowary, and Apteryx have. I have put in outline a supposed Sternum (st.) which, although not present in the preparation figured, yet undoubtedly existed in the fresh state.

A 2.—With an arrested cleft in the base of the scapula, but with the coracoid simple.

Example.—Hylædactylus celebensis, Schlegel.

Plate VI, fig. 9 shows the Shoulder-girdle of a young male of this species, as seen from above, and magnified three diameters. The specimen was from Ceylon.

In this Frog we have the supra-scapula (s. sc.) normally large, spatulate in form, two fifths of

[1] All these, except *Bufo*, have been studied from Hyrtl's preparations.

[2] See Owen on *Dinornis* (part ix), 'Zool. Trans.,' 1866, vol. v, part 5, p. 356, plate lv, figs. 2, 3, 4.

its surface covered with the outer bone, and nearly all the rest hardened, superficially, by endostosis; a narrow band of soft cartilage connects it with the scapula (sc.), which is hourglass-shaped in outline. The concave anterior outline of the scapula is interrupted by a small spur, and the *inner* face has, along its middle, a strong smooth keel, relatively larger than the outer scapular spine of the *Echidna*. Below this spine the scapula bifurcates, and the hinder, short division forms half the glenoid cavity (gl.); whilst the longer spur runs forwards, meeting the head of the coracoid: the whole scapula looks very much like a high-heeled boot with the toe part forwards. This is the normal form of the scapula in the Anoura; but the coracoid (cr.) of *Hylædactylus* is not normal, for it is merely one narrow-waisted, broad-ended bar, flattened, and yet tolerably thick, with the broadest end below; there is but little soft epicoracoid below, for the outer bone is well developed in this as in many other Frogs. This form of coracoid will reappear constantly in the Bird Class with a few modifications. The Sternum (st.) in this species is very large, and not unlike the blade of a cheese-knife; the præ-mesosternal part is broad, but the xiphisternal end (x. st.) is more than semicircular, and has produced angles, looking forwards; the whole cartilage has but one two-layered, imperfectly developed ossification (endostosis), the margin all round the plate being soft.

A 3. Supra-scapula inordinately large; scapula minute and undivided; præ-coracoid nearly as large as the coracoid, and separated from it by interruption of the epicoracoid band.

Example.—Dactylethra capensis, Cuv.

In Plate VI, figs. 10—12, the Shoulder-girdle and Sternum of this extraordinary Frog are shown, magnified two diameters. The specimen was prepared from an adult female individual. In this form the supra-scapulæ (s. sc.) are so large and thin, that they look like the epicoracoids of the Salamander turned upside down. In outline they are bagpipe-shaped, and the ectosteal bone, perfect in the narrow oblique lower part, only covers two fifths of the cartilage above. This outer bone spreads above into two unequal leaves with toothed edges, the small leaf being the one in front, and having, underlying it partly at its upper margin, an independent endosteal patch, which is kidney-shaped. The free, thin, soft edges are quite as capable of overlapping each other as the epicoracoids of the Salamandrines, and make a very ridiculous figure as the capitular and tubercular parts of "occipital pleurapophyses." The extreme variability in the relative size of morphological regions and *elements* is well shown in *Dactylethra;* for, combined with the largest supra-scapula, we find the minutest scapula (figs. 10 and 11, sc.).

This bone is a short, thick wedge, concave within, having an upper and a lower thick lip, externally, with a fossa between; and there is no trace of morphological cleaving; it is well ossified, and is separated by a narrow band of cartilage from the supra-scapula above, the præ-coracoid (p. cr.) in front, and the coracoid (cr.) below. These three bones are united in the base of a most elegant *acetabuliform* glenoid cavity, by a three-rayed suture, exactly like a Mammalian "acetabulum," and having the edge of the cup *chipped* below, for the ligament, in precisely the same manner. The præ-coracoid (p. cr.) joins the supra-scapula in front of the scapula, a most rare connection, and showing that morphological "law" is neither *blind* nor *bound*, and helps to form the glenoid cup fully as much as the scapula. A massive bone above, the præ-coracoid gradually narrows to a point, and is, on the whole, a long falciform bar, with its convex margin behind, and ending below in a jagged, thin, partially ossified cartilage, which lies in apposition to its fellow of the opposite side (Plate VI, figs. 10 and 12.) Both in this bone and the coracoid (cr.) the *Dactylethra* curiously adumbrates those Toads-in-armour (Schildkröten)—the Tortoises; for the coracoid is also a long and delicate rod, scarcely distinguishable from that of the young Green Turtle (*Chelone mydas,* see Plate XII, fig. 2, cr.); and having a similar lunate cartilaginous epicoracoid (e. cr.). This piece which has in it a small endosteal patch, runs along by its fellow for some distance; but, as far as Hyrtl's beautiful preparation shows, ends in a point a long distance from the præ-coracoid flaps (fig. 10, p. cr. and c. cr.).

The Sternum (st.) is shaped like a rose-petal, the narrowed part lying between the epicoracoids: like the Shoulder-plates it is abnormal, being unossified, as in the Urodela.

A 4. Supra-scapula scarcely larger than in *Microps;* scapula uncleft, and of great length; præ-coracoid and coracoid extremely unequal.

Example 1.—*Systoma gibbosum,* Wagler.

Plate VII, fig. 9, shows the Shoulder-girdle and Sternum of an old male of this species (from the Cape of Good Hope), seen from an antero-superior aspect, and magnified four diameters: it is a most abnormal type.

The supra-scapula (s. sc.) of this species is narrow, somewhat lunate, rounded above, margined by endosteal cartilage, which appears most in the notch at the base of the bony sheath; it is set on to the scapula at a right angle. The scapula (sc.) is more like that of a Chelonian than an Anouran, being an almost cylindrical rod, and passing by anchylosis at once into the præ-coracoid and coracoid (p. cr., and cr.). These bars are reversed as to relative size; for the coracoid is, as a rule, the largest; here, however, it is extremely small, whilst the præ-coracoid is of great breadth, especially where it meets its fellow: there is but little epicoracoid margin (e. cr.) to these bars. This curious Shoulder-girdle is almost precisely like the Hip-girdle of certain Chelonians, *e.g. Caretta caouana.* Small as is the epicoracoid band, yet the left overlies the right, and the narrow end of the oval "coracoid fenestra" (c. f.) is towards this band. The Sternum (st.) is oval, very small, and endosteally ossified; it is by far the smallest Sternum I have met with.

Example 2.—*Systoma granosum,* Duméril.

Plate VII, fig. 10, shows the postero-superior view of the Shoulder-girdle of an adult female of this species (from the Cape of Good Hope), magnified three diameters. This in many respects differs but little from that of *S. gibbosum;* the supra-scapula (s. sc.) is more pointed and straighter; the scapula (sc.) is shorter and stouter, and ends in front in a kind of projection quite similar to what I have described as the "preacetabular spur" in the pelvis of Gallinaceous Birds ('Trans. Zool. Soc.,' 1864, vol. v, part 3, p. 166).

The three bones, scapula, coracoid, and præ-coracoid, are not anchylosed together, and the two latter have entirely reversed their relative proportions; the coracoid (cr.), is now a very massive and broad bone; whilst the præ-coracoid (p. cr.) is a very small phalangoid bar. Here we have the normal proportions of the *ischium* and *pubis* of the Mammal. The coracoid fenestra (cr. f.) the counterpart of the *obturator foramen* of the Mammalian pelvis, is very small, oval, and has its narrow end pointing forwards; the reverse of what obtains in *S. gibbosum.* The Sternum (st.) is twice as large as in the former species, more normal in form, and ossified as in the other kind.

A 5. Typical in all things save in the absence of the "Omo-sternum;" the supra-scapula being large; the scapula cleft below; and the præ-coracoid separated from the coracoid by a large "fenestra."

Example 1.—*Ceratophrys dorsata,* Neuwied.

Plate VI, figs. 2 and 3 show the Shoulder-girdle of an adult male of this species (from the Brazils), fig. 2, being an upper, and fig. 3 a side view; they are both of the natural size. Here we see the large oblong supra-scapula (s. sc.), which is somewhat pinched at its middle, having its imperfect outer bony plate covering rather more than the front half; but notched below and arrested above, and having underlying it an independent endosteal growth, which still leaves much of the upper and hinder part unossified altogether. The scapula (fig. 3, sc.) is a long, flat, boot-shaped bone, of considerable breadth above, and then having an ankle-like narrowing before it gives off its præ-scapular bar (p. sc.) The bony, outer plate, which only crept from the front margin to a certain extent on both sides of the supra-scapula, has thoroughly ensheathed the scapula; so it does in the coracoid (cr.); but not in the præ-coracoid (p. cr.). This latter bone is crescentic in shape, broad above, pointed below, and is clamped on to the partially ossified cartilage like the back of a meat-saw. The coracoid, separated from the præ-coracoid by a large tear-shaped fenestra (cr. f.), is a stout ray of the typical form, that form which also we shall see to be the rule in the Bird-Class. The epicoracoid belts (e. cr.) are flattened, but are undiminished in breadth, are endosteally ossified, and do not overlap each other. The back of the glenoid cup (gl.) is seen to form a notable bulb on the inside, whilst on the outside (fig. 3) we see that it owes most of its wall to the coracoid, and least to the præ-coracoid. The Sternum (fig. 2, st., x. st.) is relatively the largest in the group, and has the præ-mesosternal region ossified by endostosis, all but the low triangular apex; the xiphisternal portion (x. st.) is unossified, and shows its primordially symmetrical character by being divided into two large neatly rounded lobes.

Example 2.—*Docidophryne gigantea,* Fitzinger.

Plate VI, fig. 4, shows the Shoulder-plates of this huge Batrachian, of the natural size, and as seen from above. Professor Hyrtl's preparation is marked as an adult female from Mexico. The supra-scapula (s. sc.) is very large, and somewhat oblong, but with a concave anterior and a convex posterior margin; the upper edge is gently rounded; ossification has advanced much further than in the last species, but is of the same character. The scapula (sc.) is a robust bone, considerably constricted in the middle, and having a very definite basal fenestra (sc. f.): its suture with the præ-coracoid is very extensive. The præ-coracoid (p. cr.) is very broad above, and then suddenly narrows, so as to become a cylindrical rod; and the bony tubing having met behind the bar approximates the posterior coracoid in character. This latter bone (cr.) is a stout but rather narrow-waisted ray, having a short suture with the præ-coracoid, and a long one, at right angles with the other, with the scapula; below, it ends obliquely at the broad epicoracoid band (e. cr.), which is hardened by endostosis. This band narrows considerably as it runs into the præ-coracoid, and the left overlies the right. The Sternum (st.) is most instructive; for although it is only imperfectly ossified, and has no outer sheath, yet it is very long, rather broad, and the three great divisions into manubrium (præ-sternum), body (mesosternum), and xiphoid process (xiphisternum) are marked out. The first division has its own endosteal patch; the next sends its patch of bone for some distance into the soft, emarginate, xiphoid region, which has no autogenous bone.

Example 3.—*Bufo agua,* Daudin and Pr. Max.

Plate VI, fig. 5, shows the Shoulder-girdle and Sternum of this species of the natural size, and from the lower aspect; so that the left supra-scapula is not supposed to be cut away as in the last, and, indeed, in most of the figures.[1]

This type comes much nearer to *Docidophryne* than to *Bufo*, and the differences between this and the last are of an indifferent nature; so that I need not give a detailed description. The scapular fenestra is not to be seen in this figure; the inner face shows it best. The præ-coracoid (p. cr.) is relatively longer, and the coracoid (cr.) straighter than in *Docidophryne,* and the epicoracoid band (e. cr.) wider in front. The Sternum (st.) is here elegantly formed, the anterior margin being arcuate, and the posterior bilobate with retral angles. There are two patches of *internal* bone (p. st., and m. st.), and the latter runs into the soft xiphoid (x. st.).

Example 4.—*Otolophus margaritiferus,* Cuv.

Plate VI, fig. 8, shows the Shoulder-bones of this species—a female from the Brazils; as seen from above and magnified three diameters. The supra-scapula (s. sc.) is of great depth, and rather broad; narrowest at the upper margin; three-fourths of it is covered with *outer* bone, and most of the rest is ossified internally. The scapula (sc.), præ-coracoid (p. cr.), coracoid (cr.), and epicoracoid (e. cr.) are quite normal or typical, and are very much like those of *Bufo agua*; but the Sternum (st.) has only one tract of endosteal bone, which affects nearly all the cartilage. In shape the Sternum is an elegant spatula, and it is relatively of a very large size.

Example 5.—*Pelobates fuscus,* Wagler.

Plate VI, fig. 6, shows the parts of the thorax in an adult male of this Austrian Toad, magnified three diameters. This, if there be such a thing, is a *generalized* form. In general

[1] This is one of the old preparations of Batrachia in the Museum of the College of Surgeons; it is described as a species *Ceratophrys*; but this is corrected in MS. in the visitor's copy of the Catalogue, see vol. i, p. 121, No. 599.

form it is very much like what we have been describing, but on closer inspection it is full of differences.

In the first place it combines the Toad-character of no episternum with the Frog-character of a shaft-bone in the true Sternum; then, instead of having "independent endostosis," this process is altogether under the influence of the ectosteal sheaths; so that the cartilage which appears beyond these plates is entirely soft; this and the large size of the epicoracoids (e. cr.) bring us back again to the Urodela. Nevertheless, the supra-scapula (s. sc.), præ-coracoid (p. cr.), and coracoid (cr.) are morphologically normal; the coracoid fenestra (cr. f.) is small and tear-shaped. The sternum (st.) is a long flattened ectosteal bar, with a rounded præsternal cartilage, anteriorly, and a transversely oval xiphoid plate, equally soft, behind.

Example 6.—*Bufo vulgaris*, Laurenti.

My dissections of the Shoulder-plates of the common Toad are figured in Plate V, figs. 15—17, magnified seven and twenty-five diameters; and in Plate VII, fig. 4, magnified four diameters: the latter is from a half-grown specimen, and the former from one a few weeks after its metamorphosis. The structures of this smallest individual are spread out to show the exact relative size of the segments. There is less of the bony sheath of the supra-scapula (s. sc.) on the upper surface (fig. 15) than on the lower (fig. 16); its jagged edges and the underlying, independent, endosteal plate are well shown. The scapula (sc.) is completely ensheathed with bone; it is a rather solid bar, and the base is perforated by the scapular fenestra (sc. f.), which is seen above, but below opens into the glenoid cavity (gl.). Over this cavity there is (fig. 15, gl.) an independent patch of intercellular bone. Like the supra-scapular outer layer, that of the præ-coracoid (p. cr.) is more below than above; it merely clamps the anterior margin of the cartilage. The coracoid (cr.) is a complete ring of bone, but it has not reached the ends of its own region; the coracoid fenestra is large and oval, and the epicoracoid (e. cr.) still quite soft, and overlaps its fellow, the left overlying the right. The most important thing to notice in this stage is the coalescence of the anterior part of the right and left præ-coracoids (fig. 17 shows this part, magnified twenty-five diameters, and in this figure are seen the proliferating cartilage-cells, lying in a profusion of intercellular substance); this is an unmistakeable Plagiostomous character; all the more to be noted because of its recurring together with "independent superficial endostosis."

The Sternum (st.) at this stage has almost acquired its permanent form; it is somewhat hourglass-shaped, slightly emarginate behind, and wholly soft.

In the half-grown species (Plate VII, fig. 4) the supra-scapula (s. sc.) is broader at the upper margin, and the anterior edge from being convex has become concave. The ectosteal layer has become hatchet-shaped, the blade lying below, and the edge looking backwards; whilst the endosteal bone has, through the rapid growth of the cartilage, become divided into an upper and a lower patch; these patches do not conform to the outer bone; the scapula (sc.), the coracoid (cr.), and the præ-coracoid (p. cr.), have advanced both relatively and really; and only the edge of the hinder, broad part of the epicoracoid (e. cr.), is now soft, for the "endostosis" has been active since the earlier stage.

The Sternum (st.) has grown longer in the body and broader in the xiphoid process (x. st.); the anterior part of the præ-sternal region, and nearly all the xiphi-sternum is still soft; the rest is ossified by endostosis only; there is, however, only one patch of this granular bone.

Example 7.—Bufo cinereus, Laurenti.

Professor Hyrtl's preparation of this Austrian Toad shows precisely the same characters as those of *Bufo vulgaris*, which, in its adult state, only differs from half-grown individuals by a fuller degree of ossification, and a somewhat more elegant shape of the various parts.

B. *With a rudimentary "Omosternum."*

Example 1.—Pipa dorsigera, Daudin.

Plate VI, fig. 1, shows the Shoulder-girdle and Sternum of a female Surinam Toad, of the natural size; it is an upper view, with the left supra-scapula removed. In many respects these structures are unique, in others we have a near approach to *Dactylethra;* whilst as to the "omosternum," it agrees with the next instance—a very different type.

The supra-scapula (s. sc.) is very large, and irregularly fan-shaped, and can be bent at less than a right angle upon the scapula: it has but little outer bone, and this is deeply cleft; but the endosteal bone extends largely along the cartilage, only the margin of which is soft for a line or two in breadth.

The anterior fork of the sheathing bone is very narrow, and clamps the anterior concave edge of the supra-scapula; the posterior part of the plate is widely divergent from the other; and, although broad below, becomes pointed and hooked above. The intercellular bone is, as in all the other plates, very compact; it reaches the posterior sinuous margin of the plate but not the upper.[1]

As in *Dactylethra,* the scapula (sc.) is extremely small; it is irregularly five-sided, having a straight upper margin and a wedge-like base to fit in between the præ-coracoid and the coracoid; it is rather thick, and is undivided. The great inferiority of the scapula to the supra-scapula in *Dactylethra* and *Pipa* is an excess of what is typical in the Anoura; they may both be called "ultra-types." Below the glenoid cavity each moiety of the Shoulder-girdle is developed into an extraordinarily large plate, quite as large as, but very different from, what is seen in the Urodela.

Each Shoulder-girdle moiety is about twice as large below the glenoid cavity as above it; and the small scapula forms a narrow waist to this two-bladed plate. Underpropping the well ossified scapula are two other shaft-bones, and between these a large cleft appears, which becomes a "fenestra," ten lines long and six broad, and having its long axis passing downwards towards

[1] Amongst the few specimens of Amphibian skeletons in the Museum of the College of Surgeons that existed prior to the purchase of Professor Hyrtl's splendid series, there has been for many years,—that is, since the purchase of Hunter's Collection, the skeleton of a *Pipa,* which has suffered equally from injuries and from repairs—more "discredited," indeed, by the latter than by the former. In the Catalogue (vol. i, p. 121, No. 601) it is thus written: "The supra-scapula is bifurcate, its anterior and longer branch resting upon the diapophysis of the atlas." Thus the little *haft* is described as though it were a perfect thing, but the huge *blade* is forgotten.

the mid-line, and backwards towards the Sternum. The posterior margin of this coracoid fenestra (cr. f.) is formed by the coracoid (cr.), and the anterior and inner by the broad epicoracoid cartilage (e. cr.); this latter margin is so accurately semi-oval that it seems as if it were artificially cut; it does not reach the mid-line of the body by three and a half lines. The whole extent of the basal cartilage is two inches eight lines, and its widening sides are to some extent converted into perfect bone by the præ-coracoid (p. cr.) in front, and the coracoid (cr.) behind. The former of these is only formed at the anterior edge, and clamps it on both sides; is pedate where it helps to form the glenoid cavity, and then becomes a narrow, slightly curved bone, which ends at the same distance from the lower edge as the "fenestra." The coracoid (cr.) has a small head, a rather more constricted neck, and then at the middle has begun to widen; so that whilst it is less than two lines wide above, it is nearly an inch across below, and reaches the mid-line within two lines. The extensive, partially calcified præ-epicoracoid cartilage runs behind the præ-coracoid outer plate, nearly to the glenoid cavity; runs in front of it against the mid-line, forming an "omosternal" lobe (o. st.), five lines long by four broad; mounts upon the front margin of the coracoid for three lines in extent, and runs round its base, forming a plate equal in size to the main bone (cr.), behind which it sends a broad ascending process. This extension of the epicoracoid *behind* the coracoid as a hook or spur is repeated again and again in the Oviparous Vertebrata, and I shall show how very marked a character it is in a large number of Birds; that which is most noteworthy in *Pipa* is the great relative size of this hook.

What is most remarkable of all in the Shoulder-girdle of this strange Toad, is the perfectly straight "harmony-suture," formed by the meeting of the right and left præ-epicoracoids (for in most of the Anoura, even when very small, they overlap); and the long, slightly sinuous "harmony-suture" of the epicoracoids with the Sternum (st.) on each side. The former suture is nearly two inches in extent; the two latter are each more than one inch. What there is of the submesial cartilage in *Dactylethra* is straight also (Plate VI, fig. 10), and in *Ceratophrys* (Plate VI, fig. 2) this line is almost straight; but for extent and perfection they bear no comparison with *Pipa*. About a line breadth of margin is left soft along the front of the "omosternal" lobe, and along the hinder margin of the ascending posterior spur of the epicoracoid (e. cr.); all the rest of the cartilage is composed of two plates of granular bone, with a pith of unchanged cartilage within.

The Sternum of *Pipa* (Plate VI, fig. 1, st.) challenges attention equally with the rest of the thorax-plates; and this, not only on account of its huge horizontal expansion, but because it is arrested at that same morphological condition which we find temporarily in the Common Frog at its first exit from the water—when it has been fairly *curtailed.* The long sutures of the Sternum with the epicoracoids have been described; they form with each other rather more than a right angle. The free edges of the Sternum are of equal length with the others, but they are concave at the middle, and swell at both ends; whilst the xiphoid extremity, not at all produced, is rounded exactly like the "omosternal" rudiments; this rounding of the free part of the Sternum spoils the otherwise very regular lozenge-shape. Measured fore-and-aft, and from angle to angle, the Sternum is more than one and a half inch; the latter measurement being slightly the longest. In the condition of its ossification it answers exactly to the præ-epicoracoid, and the free margin has the same amount of soft cartilage.

The *Pipa* seems to me to be one of those beautiful instances of "shifting of hands" which we find in nature; for surely, if there be such a thing as morphological "isomorphism," we have it here, where the whole creature is so much like a flat-bodied Water Tortoise, and where the endo-skeletal thorax-girdle as perfectly enshields this sub-reptilian creature as does the exo-skeletal box its nobler relative—the Chelonian.

Example 2.—*Pseudis paradoxa,* Wagler.

Plate VI, fig. 7 shows part of the thorax-plates, from above, of this Anouran, also from Surinam. Hyrtl's preparation was made from an adult male, and I have magnified it four diameters (sixteen in superficies), to make a comparison with *Pipa.*

This type comes much nearer the next (highest) group than the last; the only thing keeping it out of that group being the arrested condition of the "omosternum" (o. st.), the halves of which appear to be imperfectly joined at the mid-line; certainly not segmented from the præ-coracoid angle.

The bifurcate scapula (sc.), cut away above the fenestra (sc. f.) in the figure, the long, slender, grooved præ-coracoid (p. cr.), the well-ossified coracoid (cr.), and the overlapping, endosteally ossified præ-epicoracoid (e. cr.), are perfectly normal; the large, elegantly egg-shaped coracoid fenestræ (cr. f.) have their apices directed almost transversely.

c. *With a perfectly developed Omosternum.*[1]

C 1. Sternum devoid of Ectosteal Bone.

Example 1.—*Acrodytes Daudinii,* Fitzinger.

Plate VII, fig. 1, shows the parts of the Shoulder in an adult female of this Brazilian species, magnified two diameters. The supra-scapula (s. sc.) is somewhat fan-shaped, but it has that kind of asymmetry which obtains in the leaves of the *Begonia,* and some other plants, the anterior margin being longer than the posterior, and concave in outline, whilst the latter is convex; the outer bone is unequal in the same manner. The upper margin is arcuate, and most of the cartilage is affected by "endostosis." The scapula (sc.), præ-coracoid (p. cr.), and coracoid (cr.) are typical; the coracoid fenestra (cr. f.) is an ellipse, and the epicoracoid (e. cr.) is continuous with a considerable amount of præ-coracoidal partially ossified cartilage, surrounded by the outer bone; this continuous sheet of cartilage crosses its fellow, the left lying on the right.

Surmounting the anterior angles of these cartilages is a perfect "omosternum" (o. st.): it is short, spatulate, and has towards its base a deposit of endosteal bone. But the true (*costal*) Sternum (st.) is very large, and extremely interesting morphologically, being divided by "endostosis" into two equal semi-osseous halves, with a narrow line of soft cartilage between and behind them. With an obtusely irregular anterior margin, and slightly concave

[1] The Hyrtlean Collection will supply me with several instances of this culminating group; and then I shall give an account of the development of the various parts from my own dissections of the Common Frog.

sides, this Sternum ends in two elegant xiphisternal auricles, separated by a notch of their own width. This is my only example of a symmetrically ossified Sternum in the Amphibia; but it is a foreshadowing of what is constant in the Reptiles; constant, but with the addition (as a rule) of an intercalary piece in Birds, and not at all infrequent in the Mammals.

Example 2.—*Calamites cyaneus*, Fitzinger.

Plate VII, fig. 6, shows the Shoulder-bones of this Australian type, magnified three diameters; it is drawn from the skeleton of an adult male.

The supra-scapula (s. sc.) is much squarer in form than the last, and the anterior margin is convex, whilst the posterior is concave, contrary to the rule; and this change affects the length of these margins also in some degree: but the anterior lobe of the outer bone is largest, as usual, and the uncovered cartilage is partly calcified throughout most of its extent.

The scapula (sc.) has its præ-scapular fork (p. sc.) larger than the last; the præ-coracoid (p. cr.) is also longer, and its pedate base is more extended; the coracoid (cr.) is slenderer, the overlapping epicoracoid (e. cr.) narrower, and the coracoid fenestra (cr. f.) twice as large, and somewhat reniform. The omosternum is small, shark-tooth-shaped, and having an ectosteal "crown," and soft, diverging "fangs"—a remnant of the original dividing-line notching this plate behind. In the true Sternum (st.) this division is very much greater; and although these two plates are not unlike, yet the true Sternum has no ectosteal sheath; it is, however, affected throughout by "endostosis." The præ-sternal margin is rounded, and this manubrial part is only one third the length of the free, diverging "xiphisternal horns." Here we have an anticipation of the long free xiphisternals of the *Stellio* Lizard; of the Tinamou, Rails, &c., among the Birds; and of the Pangolins (*Manis brevicauda, Pholidotus Africanus*), among the Mammals.

C 2. Sternum with an Ectosteal Sheath.

Example 1.—*Cystignathus pachypus*, Wagler.

Plate VII, figs. 2 and 3, shows the shoulder-plates of an adult male (from Bahia) magnified three diameters. This is a truly elegant structure, and approaches very nearly to the highest kind of Anouran development.

The supra-scapula (s. sc.) is of the normal form, and the large ectosteal plate is hatchet-shaped; its anterior edge thick, and revealing, in the angle, a patch of unchanged cartilage, besides the soft upper margin. This depends upon the development of an upper, independent, endosteal plate, as in *Bufo vulgaris*, bearing the same relation to the supra-scapula itself that the epiphyseal supra-scapula does to the scapula in the Mammal, and even in the Reptile; it is, essentially, a rudimentary, uppermost ray, thus making three supra-glenoidal regions: in *Anguis*, as I shall soon show, the scapula itself is merely an *epiphysis* to the coracoid *shaft*.

The scapula (sc.) is a stout boot-shaped bone, with a præ-scapular fork (p. sc.) below; the posterior bar forms almost half the glenoid cavity (fig. 3). In this figure the præ-coracoid (p. cr.) is foreshortened; but in fig. 2 it is well shown, and is like a serpent's fang, only much more grooved. This groove receives the endosteal cartilage, which, as a broad band, overlapping its fellow (the left over the right), passes from the præ-coracoid to the coracoid. This latter bone (cr.) is, as usual, perfect, is not over thick, and has quite the shape of an ordinary phalangeal bone.

The fenestra (cr. f.) is of an elegant tear-shape, and is directed transversely, the small end outwards. The Sternum (st.) is composed of two parts; first, an hour-glass-shaped, but flattened præ-mesosternal *shaft*, and then of a transversely directed xiphi-sternum, which is somewhat two-leaved, has an endosteal body and soft margin, and has its angles turned forwards as in *Bufo agua* and *Hylædactylus*; but it is more elegant than either of these.

But this typical Ranine Sternum is not combined with a typical "omo-sternum," for this structure (o. st.) has no outer bone; and yet, true to its primarily symmetrical nature, it has two delicate endosteal deposits: its shape is not that of a short, but a long spatula. (See it as compared with that of *Acrodytes*, Plate VII, fig. 1, o. st.)

Example 2.—*Pleurodema Bibronii*, Tschudi.

Plate VII, fig. 5 shows the Shoulder-bones in this Chilian type, magnified four diameters; the subject was a young female.

Referring at once to the keystone of the Shoulder-girdle, the "omo-sternum" (o. st.), we see, as compared with the last instance, and with figs. 1 and 7 (o. st.) of Plate VI, how varied are the footprints of the same morphological power or force. Here (Plate VII, fig, 5, o. st.) the symmetrical, segmented cartilages have been converted into one spoon-shaped flap, with a narrow, sub-cylindrical handle, and a nearly circular, flattened bowl. The handle is a true phalangoid *shaft*, and the bowl a broad *epiphysis*; but these, at their junction, are sealed with the impress of their primordial symmetry by a neatly circular "fenestra."

Referring at once to the Sternum (st., x. st.), we find that the rounded præ-sternal end has, like most of the xiphisternal, undergone endostosis; but the hinder half of the præ-sternal region and all the meso-sternum, form together one flattened ray, which is but little pinched at the sides. The two halves of the xiphisternum are joined by a proximal isthmus for more than one third of their extent, and the primordial notch is at first rather narrow, and then suddenly widens.

The supra-scapula (s. sc.) has sinuous sides, and the upper end not much wider than the lower; the ectosteal sheath is almost symmetrical; and the inner margin of its forks bounds a subtriangular lobate space of intercellular bone. The scapula (sc.), the præ-coracoid (p. cr.), and the coracoid (cr.) are nearly like those of the last instance; but the last two bones are wider apart, the fenestra (cr. f.) being broader, whilst the elongated epicoracoids (e. cr.) do not overlap so much. This is a perfectly typical species; the Shoulder-structures, altogether, having four pairs of symmetrical and two azygous shafts (diaphyses).

Example 3.—*Plectropus pictus*, Edyoux.

Plate VII, fig. 7 shows the lower part of the Shoulder-plates (from above) of a young female of this species from Bengal, magnified six diameters. Here all the outer bones are present, and highly developed, although in this young specimen the azygous, terminal cartilages are yet soft. "Ectostosis" is more potent in this species than in any other I have examined; not excepting even the *Systomæ:* it resembles, in this respect, the Carp amongst Osseous Fishes; whilst *Pelobates* reminds one of the Lump-fish (*Cyclopterus lumpus*).

The "omosternum" (o. st.) is not very much shorter than the true Sternum (st.); but it is much slenderer; its free anterior cartilage is rounded, rather broad, and much like the free, rounded xiphisternum (x. st.). The scapula breaks into a glenoidal and a præ-scapular fork (p. sc., sc. f., sc.); and the præ-coracoid (p. cr.) is of the normal form, but very long and slender, and it is separated from the coracoid (cr.) by so long and pointed a fenestra (cr. f.) that it very nearly forms a notch, as in the Turtles, and in *Struthio camelus.* Moreover, its inner and outer laminæ have met behind, and the only uncovered cartilage is the small connection between it and the coracoid. This latter bone is of the normal phalangoid shape; but, having taken up nearly all the basal region by ectostosis, it is very broad and pedate sub-mesially, and approaches that of the Bird, when there is no distinction, in ostosis, between the coracoid and the epicoracoid. The junction of the two coracoids at the mid-line is sinuous; there is a very scant quantity of cartilage at their edges.

Example 4.—*Megalophrys montana,* Kuhl.

Plate VII, fig. 8, shows the Shoulder-girdle of this kind magnified four diameters; it was a young male from Java. The supra-scapula (s. sc.) is more regularly square than is usual, and the outer bony part is more deficient behind; yet the endosteal bone is nearly coextensive with the cartilage. The scapula (sc.) is very broad, and the fenestra (sc. f.) cleaving it below is very small; the base of the forks is very extended, so that the heads of the præ-coracoid (p. cr.) and coracoid (cr.) are broad also. The præ-coracoid is serpent-fang-shaped, and much extended forwards; the coracoid is very stout and short, is more than usually turned backwards: thus the coracoid fenestra (cr. f.) is short and broad. The epicoracoid band (e. cr.) endosteally ossified, and narrowest at the middle, is much extended fore and aft; and the left, normally, overlaps the right. The omosternum (o. st.) is very small, oval, and unossified; but the true Sternum (st.) is almost twice the average length; has a small amount of soft cartilage at each end; the anterior, præ-sternal end is angular; the xiphoid end (x. st.) is but little extended, either laterally or axially, beyond the shaft-bone. This is a long, flat, narrow-waisted bar, long enough to be made into the many segments of the mammalian Sternum.

Example 5.—*Rana alpina,* Laurenti.

This Austrian species is perfectly typical in its Shoulder-girdle; and both the Shoulder-sternum and the Sternum proper have a shaft and an epiphysis. My preparation of *Rana temporaria* does not show any internal bone in the broad end of the "omosternum;" this may be merely a matter of age. I shall not give figures of either *R. alpina* or from my own specimens of *R. esculenta,* but finish this group by describing the development of the common species.

Example 6.—*Rana temporaria*, Linn.

Plate V, figs. 1—14 show the modification undergone by the Shoulder-girdle and Sternum from the time when the hind-legs have appeared (the fore-legs being hidden behind the opercular folds) to the perfectly adult condition.

First stage, *Rana A.* The tail was full-sized in this stage, and the fore-legs, although folded up, were developing fast; the hind-legs were small, but very evident, and the long, flat-spiral coil of intestine undiminished in length and volume: thus the Tadpole was very distended in its short abdominal region, and the visceral laminæ, which had met long before, were of extreme tenuity. The Shoulder-girdle moieties at this stage are scarcely relatively larger than they are in the Osseous Fishes, notwithstanding the large size of the supra-scapula (fig. 1, s. sc.), the point of which does not reach the vertebral region; whilst, below, the distance to the mid-line (see the dotted lines in fig. 1) is very great.

The relation of the upper point of the supra-scapula at this stage is shown in fig. 2; it corresponds to the intercentrum between the second and third vertebræ, and has no more relation to the occiput than the same part in Osseous Fishes. This very minute Shoulder-girdle, which is magnified twenty-five diameters (see fig. 1), has nearly all the persistent characters of that of the adult Frog; for ectostosis has begun in all the four normal regions; and, whilst from the first the scapulæ and coracoids (fig. 1, sc., cr.) are enringed with this thin, almost structureless, calcareous film, the deposit forming the outer-bone of the supra-scapula (s. sc.) and præ-coracoid (p. cr.) is a two-edged plate, clamping the front of its cartilaginous model; and, as is normal, it is larger on the outside than on the inner face. The supra-scapula at present is twice as high as it is broad, and is like a broad knife with a sinuous back, and a convex edge; this edge is the posterior margin. There is a short handle to this knife, broader above than below, and rather constricted at the middle: it is not much flattened: this is the scapula (sc.), and is much more than its own length from the præ-coracoid. The massive glenoidal region (gl.) is all soft, and the cavity is a good distance from the scapula above and the coracoid below. This "cup" is very elongated, and has, at the middle of its outer edge, a very cleanly cut notch; near it I have shown the head of the humerus (h.), which is already well developed. The cartilage is very bulbous, both in front and below the glenoid cavity, and then the Shoulder-plate is somewhat constricted at both sides, and dilates, so as to produce distinct angles below. This region is cloven into a flat anterior, and a narrower, rounded posterior bar by the coracoid fenestra (cr. f.), which is accurately egg-shaped in outline, the narrow end being above. Flanking the anterior bulbous part, and clamping the broader anterior bar, is the thin, two-edged, præ-coracoid plate (p. cr.); and ensheathing the rounded bar behind is the coracoid (cr.), which is much like the scapula, but not half the size. The crescentic, flat, broad bar bounding the fenestra below, and running into both coracoid and præ-coracoid, is the soft epicoracoid (e. cr.). There could be seen no mark of the cleft which afterwards splits the scapula below, so that at present there is only the coracoid cleft, imperfect at both ends, dividing the continuous cartilage; for the appearance of division between the scapula and supra-scapula is quite a deception. Plate V, fig. 14 shows this part of fig. 1 magnified one hundred diameters; *ec. o.* is the ectosteal scapular sheath; *c.*, the cartilage passing into the supra-scapular region, and *pr.* the periosteum, which is only inflected because the sheath of bone has enlarged the Shoulder-plate by its own thickness.[1]

Stage 2, *Rana B.* In a few days the tail becomes reduced to half its former length and bulk; and by this time the moieties of the Shoulder-girdle have grown considerably, but not so much as the intestines have *decreased* in size, for they are as completely metamorphosed in the course of time as those of a Caterpillar when it takes on its transformations; whilst in the Tadpole the coil is extremely long, there is only a single loop in an otherwise straight bowel by the time the curtailment of the young Frog is complete. In this next stage (*Rana B.*) the tail is scarcely more than half its former length, and the reduction of the contents of the chest and growth of the cartilages have brought them not only together, but to overlap in the usual way. Plate V, fig. 3 shows a small part of the overlapping coracoids at this stage, magnified seventy-five diameters, and seen from within; and it is seen that their edges are flanked by a new growth of soft and delicate cartilage, which is in *immediate contact* with the serous membrane lining the common thoracico-abdominal cavity: this is the first appreciable appearance of the moieties of the true or costal Sternum, which is developed at a great distance from the arrested vertebral ribs, but which crops out in the basal region in correlation to the Shoulder-girdle, for which it seems to have a sort of organic affinity. It may help comparison to remark that this first tract of cartilage, which lies directly behind, *within*, and mesiad of the epicoracoid angles, corresponds to the anterior half of the human " manubrium sterni," which is, in reality, the keystone, in us, of the seventh cervical vertebra. The side-walls of this seventh somatome, and also of the six preceding somatomes, are deficient in cartilage; the ribs, in the cartilaginous stage, never being segmented off from their centrums, as they are in the thoracic region. And this is one reason why the Shoulder-girdle has been confounded with the costal girdles; for, lying in front of these latter hoops, and being the only cartilaginous bars interposed between the skin and the space containing the œsophagus and trachea, they have been supposed to lie in the same plane as the ribs. Wherever the limb-plates are coincident, vertically, with the costal arches, they and their muscles always overlap, or lie in an outer *transverse* plane. If the diagram (Plate V, fig. 2) be looked at, it will be seen that, at least, the three anterior vertebræ of the Tadpole are *cervical;* the same may be said of the ordinary Osseous Fish. I shall, throughout this paper, consider the first perfect costal arch, as homologous with our first, and the last vertebra that has ribs that are imperfect—whether on one or on both sides—I shall put down as agreeing with the last cervical in human anatomy.

Using as much as possible the old, somewhat arbitrary, but most convenient region-terms, I shall nevertheless, stand reverently aside, whilst Nature makes more or fewer vertebræ in any particular region; and, as her collocations are all so thoroughly *comfortable* as well as conformable, I am not fain to suppose that she has been under the necessity of shifting, replacing, and *misplacing* her bars, her rays, and her plates; as though a necessity had been laid upon her, and that she must, perforce, make all things according to the pattern showed to her, at any cost.

[1] At present, the præ-coracoid bar is larger than the coracoid, as in *Systoma gibbosum,* and in the pelvis of the Turtle; and the "omosternum" and true sternum have not yet made their appearance; and, moreover, this early Shoulder-plate is extremely unlike that of the Newt at a similar stage. (See Plate III, fig. 7.)

Stage 3, *Rana C.* In a few days the young Frog's tail becomes reduced to a stump two lines in length, whilst the waist has become slender, the fore legs longer and free, and the hind legs, which were the shortest, are now considerably longer than the others. In company with myriads of equally or still more ripe Fish-quadrupeds, it now seeks the dry land. At this time the Sternum (which lies imbedded in connective tissue so crowded with black pigment-cells as to make this particular demonstration the hardest in morphology) has grown into two notable lobes, pointed at the fore end, rounded outside and behind, and straight at the mid-line (Plate V, fig. 4, st., magnified seventy-five diameters). They nearly fill the angle between the epicoracoids, and have grown very rapidly since the last stage, but the moieties are perfectly distinct. In Plate V, fig. 5, the angle of the præ-coracoid (p. cr.) is shown, magnified seventy-five diameters, and in front of the bony bar a small hillock of soft new cartilage is seen (o. st.); the position of the same part on the opposite side is shown in outline; it is continuous with the cartilage inside the lower end of the præ-coracoidal bony bar; this is the first rudiment of the "omosternum," and answers morphologically to the persistent condition of *Pipa* and *Pseudis* (Plate VI, figs. 1 and 7, o. st.).

Stage 4, *Rana D.* In Plate V, fig. 6, the next condition of the Frog is shown (magnified fifteen diameters); the figure represents the Shoulder-plates spread out, and seen from below. The supra-scapula (s. sc.) is considerably broader above than in *Rana A;* but the anterior bony plate has not spread much. The scapula (sc.) has become twice as long, relatively, having crept upwards towards the supra-scapular bony plate and downwards to the glenoid cavity (gl.). The præ-coracoid sheath (p. cr.) is only a quarter the distance from the scapula, and has covered more of the cartilage, whilst the coracoid (cr.), which in figure 1 had its upper end the largest, is now almost equally enlarged at both ends; hereafter the lower end will be twice the size of the upper (see fig. 11, cr.). The epicoracoid flap (e. cr.) is much broader, and overlaps near the Sternum; its posterior angle is well developed; and the sharp upper end of the fenestra (cr. f.) has become rounded, as arrested clefts are wont to do. The glenoid cavity (gl.) is relatively less, and its notch has changed position in relation to the scapula, which now touches it. The soft projecting angles of the præ-coracoid have not only become segmented from their root, but these freed moieties have coalesced; thus the "omosternum" (o. st.) is formed (a more enlarged drawing of which is seen in fig. 7, magnified seventy-five diameters). This unossified simple keystone piece answers to the persistent condition of *Megalophrys* (see Plate VII, fig. 8, o. st.).

The keystone of the hyoid arch is formed in exactly the same manner at a much earlier period of the Frog's life. The Sternum itself (fig. 6, st., and fig. 8, st., the latter magnified seventy-five diameters) has also become one by the complete coalescence of its symmetrical halves; only a small shallow notch on its xiphoid margin remains of the primordial boundary-line. But for this notch, which is persistent, this low-conditioned Sternum would answer exactly to that of *Dactylethra* (Plate VI, fig. 11, st.): it also comes very close to that of *Pipa* (Plate VI, fig. 1, st.); but the Sternum in that type suffers "endostosis."

Stage 5, *Rana E.* As life is a "ceaseless motion," our perfected Batrachian is constantly undergoing mass-changes and molecular changes; and if examined a few weeks after its transformation, its skeletal structure will be found to have acquired several new characters.

Plate V, fig. 9, shows a first summer Frog's Shoulder-plate, as seen from above, and magnified ten diameters, The supra-scapula (s. sc.), which was like a pointed knife in fig. 1, and then had become obtusely angular by the retreating backwards of the apex, has now a much more rounded upper surface; it will, however, have to undergo a great change of form before it has the extended and arcuate upper margin of the adult (fig. 11). Besides the general extension of the ectosteal sheath, there now crops out from beneath it the intercellular bone : this deposit may have taken its cue from the applied bony layer; still it has great independence of it, as a rule, in the Anourans, and creeps to any distance beyond its boundary-line. A similar extension of both outer and inner bone has taken place in the scapular region (sc.), and it is also seen that the scapula is bifid below, although the chink (sc. f.) is very small in this species. Now is fairly seen the relative feebleness of the præ-coracoid bar (p. cr.), and the increased energy in the life of the coracoid: as for the ectosteal sheath of the former, this is its last appearance on the great Vertebrate stage of life; the præ-coracoid is dying out in the ascending scale of the Frog's specific and individual history, and, as far as my observation extends, no creature with an *amnion* and an *allantois* in its embryonic condition has this particular ectosteal sheath; for when the cartilaginous bar itself is ossified from without, as in the Chelonians and *Struthio camelus,* it is by a borrowed extension of the scapular sheath.

In Plate V, fig. 10, the relation of the supra-scapula to the scapula is seen in a figure magnified twenty-five diameters; there is no hinge, and the endosteal deposit is seen to be creeping beyond the outer layer. The "omosternum" (fig. 9, o. st.) is in a very instructive condition, for its hinder end is very broad and crescentic, its tip is bifid—a primordial mark; and an ectosteal sheath nearly enrings it, the ring being imperfect above, for the lower or outer surface of these Shoulder-bones is always the most ossified, and the first to ossify. It is most probable that in all perfect ectosteal sheaths there is a moment of time in which the bony matter lies at some particular part of the circumference of a cartilaginous rod; practically, many of these rods may be said to be quite ensheathed from the first, because the growth of bony matter all round is too rapid in many cases for the absolutely first stage to be seen. The Sternum (st.) has progressed far towards its adult condition; there is a soft præ-sternal bulb, a soft xiphisternal symmetrical plate, and between them a short shaft-bone (meso-sternum and part of præ-sternum in one): the xiphisternum, like the leaf of a *Bauhinia,* is one and yet double, as its bilobate form shows.

Stage 6, *Rana F.*—I have now to describe the Shoulder-plates of the adult Frog; and in these structures we shall see the culmination of this morphological type.

Plate V, fig. 11, shows these structures in an old male Frog (magnified four diameters), as seen from above, and with the left supra-scapula removed. This region (s. sc.) is very large, making some approach to its condition in *Dactylethra* (Plate VI, figs. 11, 12). Its general form is obliquely fan-shaped; the narrowed lower part is concave at each side; and the broad upper part, with its rounded angles, forms two thirds of a transverse ellipse. The outer plate is trifoliate, and covers one third of each surface, whilst all but the margin is affected by endostosis. The whole region is convexo-concave, like a watch-glass, the outer side bulging considerably. The scapula (sc.) has less of the foot-shape than is common in the Batrachia, the præ-scapular (p. sc.) and scapular bars being nearly equal, and but little divided by the "fenestra."

The præ-coracoid (p. cr.) is adze-shaped, for the proximal part is bent at less than a right angle on the descending narrow bar; this latter part does not cover all the cartilage behind, and the former projects nearly as far forwards as the descending bar does downwards. The coracoid (cr.) is now three times as large as the anterior bar, whereas it was once (fig. 1) only two thirds the size; it is much like that of certain Birds, having a thick swollen head, a roundish waist, and a broad, expanded, pedate base. The præ-epicoracoid margin (e. cr.) is endosteally ossified, and the submesial margins overlap in some degree. The coracoid fenestra (cr. f.) is of medium size, is ovate, and its narrow end is now below instead of, as at first, above. The "omosternum" (o. st.) has now a perfect ectosteal sheath—a shaft-bone—with no epiphyses even in this fine old male; but the posterior end is a narrow soft margin; and the anterior, surmounting the attenuated end of the delicate shaft, is a circular disc of cartilage. The sternum (st.) has a little cartilage on the præ-sternal end of the single, hourglass-shaped flattened shaft; and the xiphisternal region (x. st.) is developed into a very elegant, symmetrical, transversely extended leaf, which is notched at its retral angles, and at the mid-line behind; its anterior part is ossified by intercellular deposit, whilst a considerable margin is left in a soft state. When we come to the Marsupials and to the Armadillo, we shall see very similar xiphisternal cartilages to this in the Frog; the "omosternal moieties" have their "serial homologues" in the "Marsupial bones" of the Marsupials and the Monotremes, these parts being segmented off from the "pubis," which is the counterpart of the "præ-coracoid" in the Shoulder-girdle.

Plate V, fig. 12, shows a section of the supra-scapula and scapula of the adult Frog at their junction; and fig. 13, a section of the upper part of the supra-scapula: these figures show the structure magnified twenty-five diameters. Fig. 13 shows the perichondrium (pr.) passing over the hyaline cartilage (c.), with its clear intercellular substance, and its large proliferating cells, full of young cells; at the lower part the endosteal deposit (en. o.) is seen to be an ossification of the intercellular substance, and not an *endo-perichondrial* layer of bone like that shown in fig. 14 (ec. o.). This section is exactly like a similar slice of the skeleton of a Shark or Skate, save that the little bony masses are not so perfectly discrete.

We see in fig. 12 that the cartilage-cells become very flat where the supra-scapula (s. sc.) joins the scapula (sc.), and that the ectosteal and endosteal masses (ec. o., en. o.) have united in the scapula to form solid bone: in the centre, however, certain sphærical masses of cartilage (c.) are seen unchanged; in a higher Vertebrate these masses would, by proliferation, have changed into marrow-cells, then into fat-cells, and then perhaps would have been altogether absorbed. The projection of the endosteal masses into the base of the supra-scapula (fig. 12, en. o.) looks very much like crystallization: undoubtedly it is a crystalline deposit, rendered imperfect by the glutinous nature of the dissolving medium.

I shall now refer to the views taken of these parts in the Batrachia by some of our great anatomical pioneers: my friend Mr. Power has favoured me with the following translation; I shall insert my own nomenclature in brackets and in italics.

I may here remark that the Sharks and Skates (Plagiostomi) shed the same light on the Amphibia that the latter throw on the higher Vertebrata (the Sauropsida and Mammalia), which possess an amnion and an allantois in their embryonic condition, and which pass through their metamorphic stages at a more and more rapid rate. The earliest metamorphic conditions of the higher classes are miniatures seen for a moment; those of the Amphibia are half-sized pictures, which are held up to view for weeks and months; but in the low Cartilaginous Fishes we see gigantesque figures which are never taken down. Hence the necessity for both "gradational" and "developmental" morphology; and these two divisions of one science are nothing if not mutual; for neither is development to be studied without gradation, nor gradation without development, but both must be worked out by the same observer, and the results of both must intermarry in the same intellect before that birth of thought can take place which can be called perfect science. I shall have to refer to the Amphibians again and again in describing the structure of the nobler antitypes which they in sundry ways foreshadow; but before leaving the Amphibia I shall give the views of Dugès on the homologies of the Shoulder-girdle and Sternum of the Frog.

ANT. DUGÈS, '*Recherches sur l'Ostéologie et la Myologie des Batraciens.*' 4to, Paris, 1834.

In his section on the Shoulder (p. 62), he remarks, "We have here to examine six distinct pieces (figs. 22—31),[1] of which one has often been attributed to the Sternum, and of which another has only been described by Mertens. We will indicate, first, the names we have thought proper to give to these parts, and justify their application subsequently.

1. Ad-scapulum [*supra-scapula*], "omolite" of Geoffroy, fig. 22, No. 29[2]), the superior portion of the *omoplate* [*scapula*], always less ossified and thinner than the next; it is, nevertheless, never altogether cartilaginous in the adult; yet it is perceptible that the ossification propagates itself from the anterior and from the inferior border; it is then one single and individual piece, whether it is only in part ossified, as in Toads, Sonneurs (Ringers, Bell-frogs), and Rainettes (Little Frogs), or is altogether ossified (Frogs). It is this which refutes the argument by which Cuvier has opposed the opinion of M. Geoffroy, who sees in this piece the representation of the superadded cartilage of the scapula of young Mammifers. But this piece has also, as Cuvier truly says, its cartilage, but not distinct and separate—not connected with the osseous part as a true epiphysis.

2. Scapulum (*scapula*, No. 30[3]), always shorter and thicker than the preceding piece, and longer than broad in the greater number of the Anourous Batrachia; but broader than long, and consequently very short, in the *Bufo igneus* and the two "*obstetricans*:" it is as though bifurcated at its inferior extremity or border, where it makes a part of the glenoid cavity. Of the two branches of this bifurcation, the internal and posterior [*post-scapula*] is clearly the coracoid apophysis of the Mammifers —of Man, for example [*not so; it forms the neck and most of the glenoid cavity*];—the external and anterior (*præ-scapula*) is clearly the acromion or its commencement, the spine of the scapula.

3. The groove which separates these two eminences [*scapular fenestra*] is converted into a hole by a piece which long remains cartilaginous, but which finally ossifies separately, and appears as if intercalated between the scapula and the other pieces forming the shoulder (31[4]). This piece, which I call the *paraglenal* [*endosteal bone in cartilaginous symphysis*], and which was recognised by Mertens, represents the coraco-acromial ligament of Man, and, like it, serves to complete the articular cavity which receives the head of the humerus. It is of large size in the common Toad and in the Green Frog, but I have not been able to distinguish it in the dry skeleton of the *Bufo fuscus*.

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[1] I shall not reproduce the figures from Dugès' work, but refer the reader to my own plates.

[2] See Plate V, fig. 11, s. sc.

[3] See Plate V, fig. 11, sc., p. sc.

[4] This bony patch is shown in Plate V, figs. 9 and 15, gl.

4. A bone (32[1]) has been universally recognised as analogous to the coracoidian clavicle [*coracoid*] of Birds, which, enlarged at its extremities, articulates by the intermediation of the preceding with the coracoid apophysis of the scapula [*post-scapula*], approximates within to its congener, and appears to sustain the posterior part of the Sternum [*true sternum*]. The first of these connections would be sufficient, were fresh proofs required, to justify the name of *coracoid bone* given to this bone by Cuvier, Geoffroy, &c.

5. Running parallel to the preceding bone we see, in front of the Shoulder, another bone [*præ-coracoid*], (No. 32[2]), which articulated with the acromion apophysis of the scapula [*præ-scapula*] approximates by the other extremity to the anterior part of the Sternum, without, however, as has been supposed, articulating with it. This bone, straight in the Frogs and Toads, very arched in the *Rainette*, the *Sonneurs*, and the *Accoucheurs*, is designated by every one the furcular clavicle (fourchette), and is compared to the furculum of Birds. It is even indicated as such in the figures of M. Geoffroy (' Phil. Anat.,' pl. ii, fig. 22), although in other Reptiles this learned zoologist had exactly determined and designated, under another name, its true analogue. We believe it to be the "acromial" [*it is the præ-coracoid*]; it is the acromial [*clavicle*] of Lizards (l. c., fig. 23) and of the *Ornithorhynchus* (ib., fig. 19), a bone which in certain Mammals has already attained a great size, although still confused with the acromion (Sloths).

6. The true furculum [*præ-epicoracoids*] or furcular clavicle (No. 34[3]) is the piece regarded as sternal by some, and as belonging to the Shoulder, but without precise determination by others (Cuvier, Meckel). That which has caused it to be regarded as a dependency of the Sternum is that it has not been known in its whole length, because it long remains cartilaginous, and is even always of soft consistence, so that it becomes deformed by desiccation; moreover, its horizontal branch is masked by the preceding piece. An exact idea of this right-angled clavicle will easily be obtained from our figures (they fail to show the mesial divisional line), of which the transverse branch extends as far as the paraglenal bone [*semi-osseous synchondrosis*], and is even extended to it whilst the cartilaginous condition is still complete, whilst the antero-posterior serves as an intermediary piece between the acromial [*præ-scapula*] and the coracoidian [*coracoid*], often very elongated (Toad, fig. 26), and even prevents the bones of this name from touching one another in the middle line. It is not less remarkable that to it alone belongs the connections of the Shoulder with the Sternum, as may be seen in figs. 22, 23, 25. The furculum [*præ-epicoracoids*] remains cartilaginous amongst the *Rainettes* and the *Sonneurs;* it only ossifies very late and imperfectly in the Toads; but in all these species, and especially in the *Bombinator* (fig. 15) its antero-posterior branch is much enlarged: moreover, that of one side constantly crosses that of the other, the *right* being generally the more superficially situated. In the Frogs (figs. 22, 23, 31) the furculum [*præ-epicoracoids*], more osseous, and having at least the same consistence as pasteboard, or as the white part of a feather of a Bird, does not offer this enlargement of the antero-posterior branch, nor the above-mentioned crossing. These two cartilages, even at an early period, unite on the median line; there results, consequently, an azygous bone [*symmetrical bars, partly confluent in the young of Bufo vulgaris; see my figs.* 15 *and* 16 *in Plate V*] in the form of a T, of which only the longitudinal part has been known (Cuvier, 'Oss. Foss.,' t. v, p. ii, pl. xxiv, fig. 31,), and that has been supposed to be wanting in Toads. It has thus happened that M. Geoffroy has called it an entosternal ('Phil. Anat.,' pl. ii, fig. 22, ^{0}), whilst others have thought that the Frogs were deficient in the cartilages recognised in the Toads by reason of their great development (Meckel). Let us anticipate the objections that may be adduced against my determinations of

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[1] See Plate V, fig. 11, cr.
[2] See Plate V, fig. 11, p. cr.
[3] See Plate V, figs. 6, 9, 11, 15, 16, p. cr., e. cr.

the parts forming the Shoulder in many Reptiles and in the Monotremes. Amongst these, as amongst the Saurians, there exist two pieces, obviously comparable with our furcular clavicles [*præ-epicoracoids*], and which are designated as a double episternal by M. Geoffroy (l. c., pl. ii, figs. 19, 20, 23, l. l.), as pieces of the Shoulder not yet determined by Cuvier ('Oss. Foss.,' t. v, 1, p. xiii and xiv, m. m., and pt. ii, pl. xvii d. d.). If the relations of these pieces with the other bones of the Shoulder and of the Sternum do not suffice to enable us to recognise them as furcular clavicles [*præ-epicoracoids*], the way of exclusion conducts us to it necessarily. In effect—1. In the ideas of M. Geoffroy the true furculum would be this bone (in the form of a T, or of a cross) that Cuvier has marked *n, f, f,* for the *Ornithorhynchus, a* for the Saurians (figs. mentioned). But, according to Cuvier, a part only of the Sternum was recognisable in this bone amongst the Monotremes; he compares it to the first piece of the Sternum in the *Kabasson,* to which we may add many other Mammals [*in these there is no inter-clavicle, but a produced manubrium*], which have their first piece [*manubrium*] very much enlarged. Amongst the Saurians it is related quite naturally to the episternum of the Crocodiles [*inter-clavicle*], (plate v, fig. 5), a piece recognised as episternal, even by M. Geoffroy ('Phil. Anat.,' t. i, p. 213), and which represents perfectly the T [*inter-clavicle*] of the Tupinambis (Monitors), the cross [*inter-clavicle*] of the Lizards, and the anterior part of the Sternum (*omosternum*) of the Anourous Batrachians. In fact, under this last relation, the analogy is supported by the advanced position and flat form of the Crocodilian piece [*inter-clavicle*] of which we are now speaking; only it is in relation with the other parts of the Sternum [*true Sternum*], which does not take place amongst the Batrachians. Supposing that in the *Ornithorhynchus* [*the epicoracoids*] and the Lizards the furcular pieces [*præ-epicoracoids*] approximated to one another as in the Frogs, and the episternal [*inter-clavicle*] pushed forward, and thus separated from the rest of the Sternum [*true Sternum*], and we should have an evidently complete analogy; we should even be able to find in the handle of the posterior Sternum of the Toad (*Crapaud calamite*) the representative of the two pieces of the entosternal (*o*) of M. Geoffroy; and as to the remainder of the Shoulder, the comparison will be still more easy in holding to the determination of the latter author, excepting only his supposed furcular [*inter-clavicle*] and his episternal [*præ-epicoracoids*] bones, which, according to our views, ought to undergo a material exchange of name.

2. According to Cuvier, it is our acromial [*præ-coracoid bar*] amongst the Anourous Batrachia, that of M. Geoffroy amongst the Monotremes [*clavicle*], and the Saurians [*clavicle*], which is the true furculum [*the true furculum, i. e. of the Bird, is highly complex*]; but then we do not know to what to refer our furculars [*præ-coracoids*], we must leave them without determination. Let us observe also that the acromial [*here he means the clavicle*] is often attached to the ad-scapulum [*supra-scapula*], as in the Lizards, the Iguanas, the Scincidæ, and the *Orvet* (*Anguis fragilis*), a circumstance which well accords with the acromion, of which the base in Mammals reaches along the whole external surface of the scapula, and not to the clavicle always attached by its free extremity. I place here, in reference to the shoulder of the Anourous Batrachians, that of the "Orvet" (*Anguis fragilis*, fig. 27[1]), where we find the episternal [*omosternum*] absent, as in Toads, an osseous acromial [*clavicle*] attached to the ad-scapulum [*supra-scapula*], a cartilaginous clavicle [*præ-coracoid*], enlarged as in the *bombinator, obstetricans,* and springing very evidently from the scapula. This last is osseous, as well as a coracoid of which the form exactly resembles that of the Anourous Reptiles; and lastly, a large xiphoid [*præ-sternum*], as in the Pipas. This shoulder is evidently as similar to that of the Batrachians as to that of the Saurians.

We also establish a parallel here between this portion of the skeleton of the Batrachian and the

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[1] See Plate VIII, figs. 2, 4, 5, 6, s. sc., sc., p. cr., e. cr.

pelvis of some other animals. No other vertebrate animals in fact, seems to us better fitted to establish the resemblance of the Shoulder and the Hip already pointed out by many physiologists.

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The resemblance is striking to the pelvis of the *Chamæleon*, of which the ilium is composed of two pieces, like the scapula of Batrachians, suspended from, not articulated to, the vertebral column. The analogy is also sustained between the shoulder of these Reptiles and the os coxæ of a young Mammal (figs. 29, 29 *bis*), where we see that the iliac crest represents the ad-scapulum [*supra-scapula*]. A small ossclet, that I may call the *"paracotyleal"* (No. 51), answers to the paraglenal [*coraco-scapular synchondrosis*]. The pubis takes the place of the furcular clavicle [*præ-epicoracoids*], the ischium of the coracoid, and the sub-pubic foramen recalls the subclavicular hole of the Frog, or rather of the Toad. As to the acromial, it has no equivalent here. It has only a rudimentary representation in the *Chamæleon*, which is the little cartilaginous marsupial that the pubis supports [*answering to the omosternum of the Frog*] ; but amongst the Monotremes the analogy becomes more striking, when we see their marsupial bone occupy by its base all the superior border of the pubic bone, in the same way that the acromial [*præ-coracoid bar*] of the Anourous Batrachia covers almost all the anterior border of their clavicle [*præ-epicoracoid*]. These reflexions could be applied to the Shoulder of the Lizards, if their clavicles [*præ-epicoracoids*] were not separated by the Sternum. Our Batrachians, on the contrary, have them united [*sometimes partially*], like the pubis of Mammals, and we may still add to these analogies the depth of the glenoid cavity, the form of the humerus closely resembling the femur, and its union to the shoulder by means of a round ligament.

This lengthy but most important quotation serves to show the absolute necessity for a most severe histological study of the morphological changes that take place during the development of the skeleton of any and every creature coming under the notice of the anatomist. We have just seen Cuvier disagreeing with Geoffroy, and Dugès differing from both. Nearer home things have fared still worse, and the Shoulder-girdle not only keeps its confused nomenclature here, but it is made the subject of a supposed *peripatetic morphology*, now clinging to the occiput, and anon crawling backwards towards the sacrum.

If we bear in mind that the Anoura have not the three Shoulder-splints which are so constant in most Lizards and in the Monotremes (namely, the clavicles and interclavicle),—that the so-called "anterior sternum" is no part of the Sternum at all, but part of the Shoulder-girdle ("omosternum"),—and that the endosteal bone is very independent of the often imperfect bony sheath, we shall be able to see through this cloud of conflicting opinions. Also it may be remarked that the term "furculum" should not be applied to any structure found in the Cold-blooded Classes, for it is an ornithic structure entirely, and is highly complex and metamorphic. Even the term "clavicle" needs to be used with caution: I mean by it only the main part, such as is seen in the young Mammal before it has united with the terminal cartilages; in other words, the *pure* clavicle is a parosteal bar, a subcutaneous bone, quite independent of the endo-skeleton.

And then as to the "coracoid," it should be held in mind that it is a mere rudiment in most Mammals, the exception being the Monotremes; and this rudiment answers to part of the "head" of the typically developed bone. Another aphoristic remark may be made; and that is, that one morphological region may be made up of three histological regions—namely, outer bone, inner bone, and soft cartilage. Dugès tripped over this stumbling-stone, and to him a mere ectosteal sheath, the partial investment of a cartilage, stood for a true skeletal element.

Now, to begin with Dugès' description, it will be seen that he is quite right in making the highly developed ad-scapulum (supra-scapula) to be the true representative of the less-developed, epiphyseal supra-scapula of the Mammal; for *ectostosis* is never seen in it again, even in the supra-scapula of the Lizards, where it is, relatively, as large as in the Frogs. The scapula and supra-scapula in the Frog are, indeed, two broad "rays," one superimposed upon, and not quite segmented from, the other; whilst the lower (scapula) has really begun to undergo cleavage in the opposite (vertical) direction; this partial division into two is borrowed from the Skates. Dugès curiously misunderstands the two forks; for the posterior is not the homologue of the coracoid rudiment of the Mammifera, but the "neck" and glenoid region of the scapula itself. Also the anterior fork is more than the "acromion;" it contains it, but is properly the præ-scapula; it might be called the præ-meso-scapula: we shall see this bar differentiated into its proper elements when we come to the Lizards.

Thirdly, the "paraglenal" of Dugès is nothing but the extension of endosteal bone into the synchondrosis which unites and yet separates the three bones that surround the glenoid cavity.

Then comes the true coracoid, the upper part of which answers to the rudiment seen in most Mammals. The term "coracoidian clavicle" is vicious enough as applied to the coracoid of the Bird and the Frog, but we shall find that it is a most perfect term for the supposed clavicle of the Mole. The fifth piece is excellently distinguished from the true clavicle by Dugès, but his name for it is an unsafe one, and his conception of it was confused, for the bony piece is merely the *bark of the shaft*, the osseo-cartilaginous *pith* of which he distinguishes, most improperly, as part of another morphological region. My name for the whole band is "præ-coracoid," a name which merely expresses its relation to the better understood posterior bar. Dugès is quite right in asserting that these bars do not represent the "furcula" of Birds; and yet, as I shall hereafter show, that compound bone contains rudiments of these bars. He is quite wrong in comparing this bar with what he calls the "acromial" in the Lizards and the *Ornithorhynchus;* that bone is the *pure* clavicle. Sixthly, his "true furculum or furcular clavicle," is made up by putting together the essential part of the right and left præ-coracoids (their osseo-cartilaginous pith) and their continuation *below*—the "epicoracoids," which latter have no ectosteal plate. These two L-shaped bars he supposes to have coalesced to form the "clavicular furculum;" they seldom unite at the mid-line (see my figures of them in the young Toad, Plate V, figs. 15—17, p. cr., e. cr.); generally overlap more or less; have no splint-bone attached to them, such as forms the "furcula" in most Birds; and yet there is a grain of truth in the matter, inasmuch as the "furcula" of the Bird does contain rudiments of the "præ-coracoid" cartilages.

With regard to what Dugès says of the præ-epicoracoids of the Lizards and Monotremes, we there come across this piece of bibliography, namely, that Geoffroy called them "episternals," the *sixth* skeletal element which has received that name; whilst Cuvier's sounder judgment referred these tracts to the Shoulder-girdle.

Whilst discussing this part of the Shoulder, Dugès, like many other anatomists, confounds together very distinct parts, namely, the "omosternum" of the Frog, the "inter-clavicle" of the Lizard, Crocodile, Monitor, and Ornithorhynchus, and the manubrium of the Mammal.

The first of these, the "omosternum," is the key-stone of the Shoulder-girdle; the second, the "inter-clavicle," is an azygous Shoulder-splint—a dermal bone; whilst the last is the key-stone of the first pair of thoracic ribs, and often of the last cervical as well (where, however, the piers of the arch are aborted). Following our author, we find him speaking of the true Sternum of the Frog as a *part*, whilst the remainder, or manubrial portion, is supposed by him to be formed by what I have called the "*omosternum*" in that animal: in the Reptile and Monotreme Dugès makes up the Sternum by adding the "*interclavicle*:" we shall see that Rathke makes up the Reptilian Sternum in a similar way. At page 67 the Blind-worm (*Anguis fragilis*) is introduced; and as I shall come to that very soon, I may remark upon his views at once. His figure (plate iii, fig. 27) may be compared with mine (Plate VIII, figs. 2—7). Small as is his figure, it can be easily understood by reference to the large ones which I have given.

Dugès truly says that the episternal (*omosternum*) is absent, as in Toads, and that his "acromial" (*clavicle*) is attached to the supra-scapula, whilst the huge epi-præ-coracoids are described as "clavicles." The "præsternum," or manubrium, the only part of the Sternum present in *Anguis*, is called, as is also the Sternum of *Pipa*, "xiphoid." In the latter the præ- meso-, and xiphisternum are all contained virtually in one generalised piece, but in *Anguis* the Sternum is only correlated to the Shoulder-girdle, and scarcely answers to the whole of the Mammalian manubrium. His little figure gives the shape exactly, but the three apparent bony centres are the "inter-clavicle" and the two endosteal patches which in reality belong to the Sternum. The remainder of his remarks, which relate to the serial homologies of the Shoulder-girdle and Pelvis, are excellent.

REPTILIA.

In describing the structure of the Sternum and Shoulder-girdle of the true Saurians, I shall enrich my paper by inserting a translation (by Mr. Power) of the late Dr. Heinrich Rathke's small but most invaluable work upon the Sternum in this Class.[1]

RATHKE, '*Ueber den Bau und die Entwickelung des Brustbeins der Saurier*,' pp. 1—7. 4to, Königsberg, 1853.

§ 1. A Shoulder-girdle and a Sternum have hitherto been unacknowledged by anatomists and physiologists in several of those species of Saurians whose form resembles that of Snakes, and which were formerly on this account actually enumerated amongst the Snakes; but from my investigations it may reasonably be concluded that the bony girdle of the Shoulder is present in all the Snake-like Saurians, and that the Sternum only fails entirely in the footless Saurii Annulati.

§ 2. In three species of the small group of Saurii Annulati, namely, in *Amphisbæna fuliginosa, Amphisbæna alba,* and *Lepidosternon microcephalum,* I found between the lingual bone and the most anterior ribs, but much nearer to the latter than to the former, a pair of small bones, which may be considered as the rudiments of a Shoulder-girdle [*coraco-scapula*[2]]. In *Amphisbæna fuliginosa,* where its dark brown colour, which is common to it and to the other bones of the skeleton, first led me to remark them, they form cylinders, the length of which was only one line (one twelfth of an inch), and the thickness only one eighth of a line, even in the largest of four specimens, the length of which was thirteen and a half inches. Their direction, when the animal was placed on its belly, was somewhat oblique from above downwards and inwards.

In a specimen of *Amphisbæna alba,* whose length was one foot six inches six lines, they were also only one line long, but proportionately somewhat thicker than in the former species. They also did not possess a regular cylindrical form, but were somewhat thinner in the middle than at their rounded ends, the transverse diameter of which amounted to one sixth of a line. Their colour, like that of the remainder of the skeleton, was white, and their direction, like that of the preceding species, nearly perpendicular. In a *Lepidosternon microcephalum* having a length of one foot nine inches six lines the rudiments of the Shoulder-girdle [*coraco-scapulæ*] had the form of beans, though somewhat more flattened on their surfaces. Their size in relation to the whole body was still smaller than in the *Amphisbænæ* that were dissected, for they were scarcely a line in length, and their greatest breadth was only a little more than one third of a line. They were white in colour, and the direction of their greatest diameter was perpendicular. In all three species the bones in question lay at a considerable distance from the vertebral column and from one another. Moreover, they were not connected by means of ligaments, either with the vertebral column, with the ribs, or with each other, but were retained in position by

[1] Whilst these sheets were passing through the press Professor Huxley put into my hands Dr. Carl Gegenbaur's most important memoir, 'Untersuchungen zur vergleichungen Anatomie der Wirbelthiere,' Zweite Heft, August, 1865. I must refer the reader to the work itself, as my acquaintance with it was made too late for me to analyze its contents.

[2] The terms in brackets and italics are added to make Rathke's description harmonise with my own.—W. K. P.

muscles, some of which were attached to them, whilst others only covered their outer surface. Of the muscles that were attached to them there were four pairs. The first pair originated from the two ends of a strong occipital ridge, passing from thence obliquely downwards and backwards, presented a moderate thickness, expanded considerably in a fan-like form, and corresponded in their origin and direction to the sterno-cleido-mastoids of other Saurians. Still, only a few of their fibres were attached to the bony pieces in question, the greater part being inserted into the cutaneous investment. The second pair of muscles were rather long, thin, and moderately broad. They extended from the lingual bone divergingly and obliquely backwards and upwards to the bony pieces, and clearly represented the mm. omohyoidei, which are also thin in other Saurians, but in relation to their length are of moderate or even of considerable breadth. The muscles of the third pair pass from the two bony pieces backwards and downwards to some of the anterior ribs. They expand fan-like, and may be regarded as the representatives of mm. serrati antici majores of other Saurians. The two remaining pairs lie external to the third pair, but extend further back, and run more obliquely downwards, forming two thin, and anteriorly only small, but posteriorly broader, muscular layers, and were with their broad ends attached to the skin.

The connection in which the two bony pieces stand with the muscles which correspond to the mm. omohyoidei and to the serrati antici majores of other Vertebrata sufficiently proves that they are to be regarded as scapulæ. But their further relations with those muscles which correspond to the sterno-mastoids in their attachments render it probable that they also, in part at least, represent the clavicles [*coracoids*].

I was unable to find any rudiment of a Sternum either in *Lepidosternon microcephalum* or in the *Amphisbæna.*

In *Trogonophis Weigmannii,* another footless Annulate Saurian, there are two bony pieces similar to those above described.

According to Rudolph Wagner's drawings,[1] they have a similar form as in *Amphisbæna fuliginosa,* but are proportionally larger, and come into contact below.

Chirotes canaliculatus (see Plate VIII, figs. 8—10),[2] the only Annulate Saurian with anterior limbs, not only possesses a Shoulder-girdle, but also a Sternum. According to J. Müller, who examined and sketched a skeleton of this animal contained in the Paris Museum, the Shoulder-girdle of this animal consists of two bony pieces, which represent the scapula and clavicles [*coracoids*]. The illustration he gives shows that it has a similar form to those of *Amphisbæna* and *Trogonophis,* though they are broader at their lower ends, where they are connected with the Sternum. The Sternum [*præsternum*] has the form of a shield, and possesses at its posterior end a much smaller elongated piece of triangular form [*meso-xiphisternum*], and with its base turned backwards, as an appendage. The ribs do not appear to be connected with this relatively extremely small sternal bone.[3]

§ 3. Amongst the Snake-like or Atypic Saurii Squamati the Shoulder-girdle and the Sternum are least developed in *Acontias meleagris,* as far as is at present known. The Shoulder-girdle consists in it, as in the Annulate Saurians, of two simple bones [*coraco-scapulæ*] lying on opposite sides of the body and between the lingual bones and the anterior ribs. Their size is, however, proportionately larger than even in the *Amphisbæna.* In one example, which was nine inches six lines long, the length of each amounted to one line and two thirds, and the greatest breadth to about half a line. They appear as thin plates, moderately broad in proportion to their length, terminating in blunt points and slightly

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[1] 'Icones Zootom.,' Leipsic, 1841, pl. xiii, figs. 20 and 22.

[2] The references are made to illustrations in the present work; there are no figures in Rathke's Memoir.

[3] 'Zeits. f. Physiol. v. Tiedemann und Treviranus,' vol. iv, p. 259, pl. xxi, fig. 12 *b*.

arched on their flat surfaces. They have an oblique direction from above downwards, backwards, and inwards. They lie on the two sides of the œsophagus and trachea, and approximate so closely to one another under the latter that the breadth of the space intervening between them is less than the diameter of the trachea. At their lower ends they are connected with one another by a very thin but strong strip of fibrous tissue, which attaches them together beneath the trachea. Three pairs of muscles are connected to them, two are comparable to the omohyoids, and are of moderate length and breadth, but very thin. These muscles about the middle of their extent have, like the muscles bearing this name in many other Scaly Reptiles, a transverse small tendinous intersection (inscriptio tendinea). They proceed from the horns of the lingual bone straight back to the bones in question, attach themselves to nearly the whole length of those horns, and lie, as is frequently the case in the Scaly Reptiles, so close to one another that the trachea can only just be seen between them.[1] Two shorter and much smaller but thicker muscles than the former extend from the lateral parts of the cervical vertebræ obliquely backwards and somewhat downwards to the upper ends of the two bones, and correspond to the levatores scapularum of other Scaly Reptiles. The muscles of the third pair pass from the five anterior pairs of ribs forwards to the bones, and consist of two bundles of moderate breadth and thickness, and are the serrati antici majores of other Reptiles. But there are yet other muscles which are *not* attached to the two bony pieces, because the three pairs already mentioned correspond only to those muscles of other Vertebrata which are adherent to the scapula. These bones are also to be regarded as simply scapulæ. Close behind the posterior extremities of the small scapulæ, imbedded in a thin layer of fibrous tissue, and situated also behind the approximated anterior extremities of the muscles corresponding to the serrat. ant. maj., which are attached to the most anterior pair of ribs, there may be found in *Acontias meleagris* two bony plates [*præ-sternum*] of elliptical form lying in close proximity to one another, the length of which did not amount to quite a quarter of a line even in the largest of two specimens that I dissected, which measured nine inches six lines. From their position they might be regarded as rudiments of a Sternum. As the earthy salts had been withdrawn from them as a consequence of maceration in hydrochloric acid, small groups of two to four cartilage-cells could be discovered in the remaining cartilage.

§ 4. In the remaining atypical Scaly Reptiles examined, viz. *Ophisaurus ventralis*, *Anguis fragilis*, and *Pseudopus Pallasii*, both the Shoulder-girdle and the Sternum are developed to a considerably greater extent than in *Acontias meleagris*. According to the statements of Heusinger,[2] J. Müller,[3] and Stannius,[4] the Sternum is wanting in *Anguis* and *Ophisaurus*, but these statements have been corrected by G. Cuvier in the second edition of his 'Leçons d'Anat. Comparée,' vol. i, p. 253.

In all three species of the above-mentioned Scaly Reptiles the Sternum is composed of two azygous (unsymmetrical) pieces very different in form and size, the smaller one [*inter-clavicle*] lying under the larger, and firmly connected with it by fibrous tissue. The larger one [*præ-sternum*] is a tolerably long but thin plate, whose transverse diameter is the longest, and is on its upper surface slightly concave from right to left, and on its lower surface slightly convex. In *Ophisaurus* the form of this plate is oblong, but it is slightly excavated at its extremities as well as at its posterior border. In *Anguis* (see Plate VIII, figs. 6 and 7, st.), the ends are bluntly pointed, and it is excavated to a tolerably broad and deep extent both at its anterior and posterior borders. In *Pseudopus* it was nearly in the form of the longitudinal section of an olive, *i. e.* it is slightly convex at its anterior and posterior

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[1] The sternohyoids are wanting.

[2] 'Zeitschrift f. Organische Physik,' B. iii, p. 496.

[3] 'Zeits. f. Physiol. v. Tiedem. and Treviran.,' B. iv, p. 227, 1831.

[4] 'Lehrbuch du vergleich. Anat. v. v. Siebold und Stannius,' B. ii, p. 139. Berlin, 1846.

borders, and rounded at the smaller ends.[1] According to my measurements, the proportion of its length to its breadth = 1 to 4 in *Angius fragilis*, in *Ophisaurus ventralis* = 1 to 3·2, in *Pseudopus Pallasii* = 1 to 2·5. Its proportion to that of the whole body is only very small; for even in *Pseudopus Pallasii*, in which I found it to be greatest, its length is to that of the whole body only as 0·02 to 1. The structure is cartilaginous, of which the greater part, though not all, is ossified. In *Ophisaurus* the plate is cartilaginous, at all its edges especially, and for a considerable depth at its posterior sharp edge; in *Anguis* at its anterior and posterior edges, though to a less extent; in *Pseudopus* only at its posterior edge, and to a slight extent. The ossified part exhibits a cartilaginous basis with low powers, and appears at its surface, on account of little knobs, somewhat uneven when the bone has been dried. These granules have roundish, or oval, or frequently irregular, forms, lie moderately close together in *Pseudopus*, but less close in *Anguis* and *Ophisaurus*, and measure 0·0030 of an inch. If the thin sternal plate of *Anguis fragilis* be examined under the microscope, it will be found that at the outer surface of its anterior and posterior cartilaginous borders only very small and simple cartilaginous cells are present, but nearer the deep or attached border of the cartilage the cells attain a larger size, and contain two or four or, though rarely, six daughter-cells in their interior; and further, each of the granules above mentioned as existing on the surface of the bony plate consists of a group of such enlarged cartilage-cells, filled with a brood of others, the walls of which are penetrated with lime salts. The walls of these ossified mother-cells of the cartilage have sharp outlines, a smooth surface, and are so thin and transparent that the contents of the contained daughter-cells (which is a soft, slightly granular substance), besides the remains of the nuclei, can be distinctly perceived.[2] If the sternal plate be divided, there may be seen on the cut surfaces, in each of the ossified mother-cells that have coalesced with one another and with the ossified walls of the daughter-cells, one, two, or three very thin and perfectly smooth septa traversing it, so that the space included by each mother-cell appears to be divided into two or more chambers. I have not observed either indentations or outrunners (canaliculi) on the walls of these chambers, which might have extended from the surface of the ossified mother-cells into the intervening matrix. The above-described compound bony cells are arranged at distances of about 0·0025 of an inch, and even in the thickest part of the sternal plate are only in rows of three or four deep.

The material which occupies the intervening spaces is of about the same consistence as the matrix of cartilage, and when fresh and moist appears semi-transparent and homogeneous. When dry, however, numerous fine calcareous granules are seen, making it appear as though it were permeated by fine fibres in various directions. Upon the whole, it is only very incompletely ossified, and from this circumstance, as well as from its thinness, still remains pliable. A structure essentially similar to that seen in *Anguis fragilis* is possessed by the plate or larger piece of the Sternum in *Pseudopus Pallasii*. The compound bone-cells, however, which constitute the greater part of the mass, have a diameter of 0·0040 inch, and also have somewhat thicker walls than in the Blind-worm.

The other or smaller piece of the Sternum [*inter-clavicle*] is so placed beneath the larger that it extends, though to an insignificant amount, forwards beyond the border of the latter. In *Anguis*

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[1] J. Müller found in *Pseudopus Pallasii* the posterior border of the Sternal plate convex (see above reference, pl. xix, fig. 2); on the other hand, R. Wagner depicts it slightly concave ('Icones Zootom.,' p. xiii, fig. 26). The form of the plate, therefore, appears to vary in *Pseudopus* to some extent.

[2] These compound ossified cells have an appearance generally similar to those represented by Kölliker in the second volume of his 'Microscopic Anatomy,' 1850, at fig. 95, as taken from the os pubis (Schambeinfüge) of Man, but lie somewhat closer.

fragilis (see Plate VIII, fig. 6, i. cl.) it resembles a heart on playing-cards, but is much broader in proportion to its length, and lies so that its smaller end is turned backwards. In *Ophisaurus ventralis* it is a longer and smaller fragment which attaches itself to *the anterior edge* of the other piece, and has in front a long but only very shallow excavation, and on the opposite side is provided with a broad, short, and rounded flat plate, which is directed backwards. In *Pseudopus Pallasii* it consists of a slight, arched strip, moderately broad in the middle, but pointed at the ends, with its convex border directed forwards, while a moderately long, small, and pointed prolongation projects from the middle of its concave border.[1] In proportion to the other piece of the Sternum, the piece in question is smallest in *Anguis* and largest in *Pseudopus*. Its texture is also a strong and hard bony substance, in which no compound bone-cells but only quite simple bone-cavities (the so-called bone-corpuscles) are present from which many branched processes or canaliculi proceed, and some of which are rounded, but the greater part spindle-shaped. The Sternum is not connected closely and firmly with *several* ribs in any of the already mentioned Saurians. Nevertheless, the larger piece of the same [*præ-sternum*] and the first pair of ribs approximate closely, and are brought into connection by connective tissue.

I shall follow Rathke's division of the Reptiles (excluding the Ophidia proper, which have no Limb-girdles), into—

1. "Sauria Annulata," or the *Amphisbænæ*.
2. "Sauria Squamata Atypica," or Anguians.
3. "Sauria Squamata Typica," or Lizards.
4. "Sauria Loricata," or Crocodiles.
5. "Testudinata," or Tortoises.

Of the first group I am able to give one instance, and that the highest, viz. Chirotes—this is from Professor Hyrtl's preparation.

The second group will be illustrated by four stages of *Anguis fragilis*, from my own dissections, and a reference to these figures will help the reader to understand Rathke's description.

My own account of *Chirotes* and *Anguis* will now follow Rathke's description; and this will give me an opportunity of commenting upon this part of his work.

I shall afterwards give his account of these parts in the third, fourth, and fifth groups.

[1] A very accurate representation of this piece of the Sternum has been given by Müller, loc. cit., p. xix, fig. 2.

THE TRUE REPTILES.

1. "SAURIA ANNULATA." The *Amphisbænæ*.

A. *With a rudimentary Shoulder-girdle, but no Sternum.*

Example 1.—*Amphisbæna fuliginosa*, Linn.

Each moiety of the Shoulder-girdle is a small cylindrical bone of a dark brown colour, and one line long by one eighth of a line thick in the adult; direction almost vertical, but turned obliquely downwards and inwards; this is evidently a "coraco-scapula," not cleft either vertically or transversely (see transl. of Rathke, p. 90).

Example 2.—*Amphisbæna alba*, Linn.

Each moiety of the Shoulder-girdle is like a small phalangeal bone, the ends being clubbed, and the middle rather pinched; length in the adult as in the last, but one fourth thicker; colour white; morphological nature, a "coraco-scapula" (see transl. of Rathke, p. 90).

Example 3.—*Lepidosternon microcephalum*, Spix.

The length of each moiety in the adult is the same as in *Amphisbæna alba*, but the breadth is twice as much, namely, one third of a line. The piece is bean-shaped, and placed with the long diameter vertical to the axis of the body; white in colour; nature, "coraco-scapula" (see transl. of Rathke, p. 90).

Example 4.—*Trogonophis Weigmannii*, Kaup.

The moieties of the Shoulder-girdle are similar to those of *Amphisbæna fuliginosa*, but larger, and meet each other below (see Rudolph Wagner's 'Icones Zool.,' Leipsic, 1841, pl. xiii, figs. 20 and 22 (and transl. of Rathke, p. 91).

B. *Possessing both Shoulder-girdle and Sternum.*

Example.—*Chirotes canaliculatus*, Cuv.

Rathke (see p. 91) had not seen a skeleton of this Amphisbænian, which has small fore feet and a highly developed Sternum; but I am happy in having access to the skeleton of an adult male from Mexico, in the *Hyrtlean* collection now enriching the Hunterian Museum.

My figures are given in Plate VIII, figs. 8—10. They are magnified nine diameters; fig. 8 shows the Shoulder-girdle and Sternum *in sitû;* fig. 9 the outer view; and fig. 10 the inner view of the left Shoulder-plate.

This minute, nearly vertical Limb-girdle is, by its histological development, subdivided into three superimposed morphological regions.

The first of these is the supra-scapula (s. sc.), which is sub-lunate, and broader than deep: it is only ossified, as in Lizards generally, by endostosis. Continuous with this is the scapula (sc.), a phalangoid ray, having its broad upper and lower margins sloping downwards in front; a long, narrow, sub-cylindrical body, and a foot-shaped base, which is scooped on its outside, posteriorly, to form the upper half of the neat glenoid cavity (fig. 9, gl.). The whole of the scapula is invested with an ectosteal sheath, so that it is a perfect shaft-bone, with the supra-scapula arrested as its epiphysis. The lowest division is twice as large as the uppermost, and is like it in shape, only that it is *inverted*, the blunt-pointed end being directed forwards and upwards, that of the supra-scapula being backwards and downwards. This is the coracoid (cr.), or rather the whole coracoidean region, præ-, epi-, and post-coracoid all in one low, broad, thoroughly ossified shaft-bone. Outside, near the hinder margin, it makes the bottom part of the glenoid cup (fig. 8, gl.); and a little below its articulation with the scapula, in front, the nerve-passage can be seen (fig. 10). This coracoid is very thick at its sinuous upper margin, scooped at the middle, and somewhat thickened again in the extended epicoracoid region; this part is nearly invested with the general ectosteal covering, for but a little of the *inner* bone can be seen.

This is a very generalised structure, but in respect of its perfectly ossified scapula it stands higher than my next example of a Lacertilian Shoulder-plate; but there is no "coracoid cleft," such as we have seen in the Amphibia, and shall see also in most of the Lacertilia.

Professor Hyrtl's preparation shows no splint-bones, as far as I can see with a pocket glass: and in this, as well as in the undivided coracoid, we have the Chamæleon forestalled (see Pl. 11, figs. 4, 5).

In the whole range of vertebrate morphology there is nothing more beautiful or more instructive than the relatively large Sternum of *Chirotes;* for if the Sternum of the Human embryo were to be demonstrated apart from the costal girdles, one diagram would serve to explain both that and what we find in this little Snake-lizard. The three typical transverse divisions, namely, the præ-, meso-, and xiphi-sternum, are all perfectly marked out here, whilst the greater part of the primordial line (the thoracic "fontanelle," so to speak) is persistent. If the ribs had not been arrested there might have been seen the counterpart of our first dorsal (and perhaps also, as in many Lizards, of the last cervical) ribs, attached to the sides of the manubrium, behind the "coracoid grooves;" at the junction of the præ- and meso-sternum there might have been the exact homologue of our second ribs; then a series of thoracic ribs; and lastly, free xiphisternal horns, as in most Mammalian embryos, and also in some adults, as in certain species of Pangolins (*e.g. Manis longicauda* and *Pholidotus africanus*, see Pl. 22, fig. 13). This is a most striking instance of what we so frequently meet with, but which is always puzzling at first sight, namely, the cropping out of the distal part of an arch (or arches), the sides of which are aborted. The correlation of the præ-sternum with the broad coracoids has resulted in its being five times the breadth of the meso-sternum; it is one and a half line in length and one and one fifth line in breadth, and is sub-hexagonal in outline. The antero-lateral margins (Plate VIII, fig. 8, p. st.) are concave (lunate), and they end in a subfalcate horn on each side; these horns are separated by a cleft, which is wide at first, then narrow, and broad again where it terminates near the middle of the præ-sternum. The hinder half of the middle is occupied by an isthmus of soft cartilage, then an oval fenestra (p.st. f.), and then there is a smaller isthmus, which is ossified as much as the main part of the Sternum, namely, by "sub-central endostosis." The short, ribless sides are at first almost straight, and then they are concave as they narrow towards the meso-sternum. The coracoid margins are thickened, as in Lizards generally, and then the præ-sternal plate becomes thinner for the rest of its length. The meso-sternum (m. st.) is one line and four fifths in length, its parallel moieties are each one tenth of a line in width; they are a little enlarged at each end, but on the whole they are very uniform bands; they, like the præ-sternum, have no ribs attached to them.

The next division is composed of the "xiphisternals" (Plate VIII, fig. 8, x. st.); these are of the same breadth, or nearly, as the meso-sternal bands, and they are one line and one fifth in length; they are somewhat clubbed where they join the meso-sternals, are greatly curved outwards, the convex margin being behind or within, and their posterior free ends are clubbed and rounded. The ossification of all the parts of the Sternum is evidently typically Lacertilian it being "subcentral endostosis;" and what is more, the segmentation, transversely, into the three typical regions, is by an *arrested* transverse cleaving; for here, as is so common in the lower part of the costal arches of Lizards, there is a pith of cartilage not cut through by the natural cleavage of the parts, and it is this which so long resists endostosis in this Class, lying as a thin innermost plate of soft cartilage in flattened parts, and as a delicate rod surrounded by bone (which bone itself has a bark of soft cartilage) in rounded rods.

It is evident that J. Müller's description, given by Rathke (transl., p. 91), gives the whole meso-xiphisternum as one piece; the xiphisternals, with the dried intervening membrane, forming the broad end of the long triangular *appendage* to the shield-shaped manubrium; it is possible that these bands differ in different individuals, both as to relative length and as to the degree of divergence of the xiphisternal horns.

I shall have to refer to these structures of *Chirotes* several times before my descriptions are finished.

2. "Sauria squamata atypica."

Shoulder-girdle and Sternum both present.

Example 1.—*Acontias meleagris,* Linn., sp. See transl. of Rathke, p. 91.

Example 2.—*Ophisaurus ventralis,* Linn., sp. See transl. of Rathke, p. 92.

Example 3.—*Pseudopus Pallasii,* Cuv. See transl. of Rathke, p. 92.

Example 4.—*Anguis fragilis,* Linn.

Rathke's description of the Sternum of this species has already been given (p. 92) with those of the other three instances; but he treats of the inter-clavicle as part of the Sternum, and gives no account of the Shoulder-girdle. We now come very close to the typical Lacertilia, and I have been profuse of large illustrations of the Shoulder of this species, that I may be better prepared to illustrate the more highly segmented, and more fully developed parts in the perfected Reptile. The

Blind-worm (Orvet) may be taken as the type of its own group; and it will illustrate the fact that these limbless Scincoids are the highest of the Worm-shaped Saurians, the Amphisbænæ being next below them, whilst the true Ophidia lie at the base of the whole Class.[1]

In *Anguis* we find three Shoulder-splints; two cartilaginous moieties of the true Shoulder-girdle, each divided into five regions, but nowhere segmented through; and in correlation with these halves there is a well-developed præ-sternum, not continuous with the ribs, and answering to the lower part of the last cervical and the first thoracic arch.

Anguis A.—My youngest Blind-worm was three inches long, scarcely larger than the figure given of its own clavicle (Plate VIII, fig. 2, cl.). This figure, showing also the rest of the shoulder, is magnified twenty-five diameters. Besides the presence of the splints, which are so profuse in the Fishes generally, but are absent in the Amphibia, we note here a deficiency of proper shaft-bones, quite as great as occurs even in the Urodelous Amphibia (see 'Axototl;' Plate VIII, fig. 1).

The upper part of the shoulder-plate of *Anguis* (Plate VIII, fig. 2, s. sc., sc.) is like a pruning hook, the lower and much larger part (p. cr., cr., e.cr.) is not unlike a ploughshare. The anterior angle of the supra-scapula is rounded off, the posterior is produced backwards and down to the glenoidal region, the posterior margin is sinuously concave. The scapular neck is rather narrow, and it then widens gently into the two parallel regions below. The supra-scapula is unossified, and the scapula is a mere *epiphysis* of the coracoid (cr.). This epiphyseal bony matter is no longer peripheral, as in the Anoura; but it is subcentral, as in all the Reptilia proper; so that whenever a *cloud* of bone appears, there the tissue is composed of five layers besides the perichondrium, viz. two outer and one innermost layer of nucleated cartilage-cells, and a pair of *subcentral* layers of endosteal bone, the immediate calcification of the daughter-cells of the cartilage. This condition is persistent wherever there is no ectostosis, and this description is true of all the Class. The best defined morphological region is the coracoidean (cr.), for this notably has undergone ectostosis, in addition to the inner calcareous growth; but it is separated to a great extent from the præ-coracoid by a large cleft, which, however, is arrested at both ends (cr. f.). This is the only *morphological* subdivision of the plate; it is indebted to the different *histological* regions for the others.

The coracoid is of the usual phalangiform shape; but the præ-coracoid (p. cr.) is everywhere broader than the neck of the coracoid; it is continued downwards from the scapula to the epicoracoid (e. cr.), and it receives some bony matter from both regions, but has none of its own; its scapular root is the "præ-mesoscapula," as in the Frog. We look in vain for any sign of a "glenoid" cavity in *Anguis*, for the scapular region passes into the coracoid almost insensibly (fig. 2, sc. cr.). If the ordinary nerve-passage has any existence, it is in the membranous fenestra, and does not pierce the head of the coracoid, as in the Frog. The Shoulder-plate becomes one again beneath the fenestra. This part—the epicoracoid—is a very large oblong, anteriorly hooked plate, very thin, elastic, and diaphanous; the left underlies the right to some extent. All but the headlands of this large territory is occupied by feeble endosteal deposit (a coracoidean epiphysis). This bony region is irregularly triradiate; a small ray ascends into the root of the præ-coracoid; another runs backwards under the coracoid; and the largest sweeps forwards in an elegantly lunate form towards the front hook of the Shoulder-plate. Loosely connected with

[1] I hope to show this fact, at some future time, in a paper on the Reptilian Skull.

these overlapping, squamous Shoulder-plates, we see a pair of sigmoid rods, thoroughly ossified, and quite unlike the structures they undergird; these are the clavicles (cl.), equally like those of an Eel and those of a Man. Like the clavicles of an Eel, and unlike those of a Man, these are *pure* splints (subcutaneous exoskeletal bones); and Dugès, in his work on the Batrachians, has wrongly figured these bones with a knob of cartilage on the lower end (see his plate iii, fig. 27, No. 33). Nature has evidently set these clavicles here as a landmark to anatomists in their long morphological journey from the worm-like Eel to the highest of the Mammalia; and the continuity of the whole clavicular series is thus clearly revealed. The backward curve of these bones is very elegant, and the whole form is "a line of beauty and grace," looking as though the same fingers had bent them as those which moulded our own collar-bones. The other splint, the *interclavicle* (i. cl.), is strapped on to the antero-inferior part of the præ-sternum, occupying its primordial fissure, and is at present composed of two pairs of bone, one hammer-shaped and the other drop-shaped, but both soon to melt into one nodule. Plate VIII, fig. 3, i. cl., shows these two symmetrical nuclei as magnified 125 diameters; they are seen from below, and lie in loose areolar tissue in the gap between the front edges of the sternum.

Above the Ganoid Fishes, this is the only instance I can give at present of the primordial symmetry of the inter-clavicle; but a careful study of the development of this bone in embryo Lizards would, very probably, show it to be not at all rare. No one could have better described the difference between this bone and the Sternum than Rathke, and yet he always calls it the "anterior sternal bone." Nearly every other anatomist, however, has made the same mistake, and the inter-clavicle has for a long time past "blinded the eyes of the wise."

The true Sternum of the youngest Blind-worm (Plate VIII, fig. 2, st.) only answers to the anterior half of the first division of that of *Chirotes* (fig. 8, p. st.), and belongs therefore to the last cervical vertebra. The two halves, the right being the largest, are united behind by a narrow isthmus, but are separated by a large primordial notch in front; each piece is pear-shaped, and the broad ends come to the mid-line. The oblique anterior margins are grooved for the epicoracoids (e. cr.), and the posterior free margin is continuous, and is as though it had been gnawed. Each moiety has its own *internal* double bone-plates, which shine through the clear, compound-celled cartilage; these right and left sternal bones are bordered by a rather wide margin of soft cartilage.

Anguis B.—My next specimen was three inches ten and a half lines in length; half its Shoulder-girdle is shown in Plate VIII, fig. 4, magnified twenty-five diameters, and seen from without. Here the scapular bone-substance, which was bifurcate on the right side in the last, is creeping upwards as a trilobate plate. The coracoid (cr.) is thicker throughout; but the epicoracoid bony plate is less in proportion to the cartilage than in the last: the clavicle (cl.) is very much thicker; it reaches, as is usual in the Reptilia, to the supra-scapula above, and beyond the præ-epicoracoid angle below; any one who has studied the Shoulder-splints in Fishes will see no difficulty in this.

Anguis C.—The next Blind-worm was almost full-grown; figure 5 shows its two Shoulder-plates seen from above, and magnified fifteen diameters. The præ-coracoid band (p. cr.) is only well seen in this figure, and the difference of the right and left sides as to bony growth is made manifest; for on the left side the meso-præ-scapular bone grows towards the præ-epicoracoid; whilst on the right side these patches do not approximate, and there is a quite distinct lower præ-coracoid patch. This bony centre, with its circumambient cartilage, is the large, generalised representative of the small specialised patch which breaks out near the sternal end of the clavicle in the Mammals. The semi-osseous epicoracoid, lying more in front of than below the coracoid, is seen to be the true morphological counterpart of the epicoracoid of the Monotreme, in which this part has an *ectosteal* sheath, as well as the coracoid; and in which the coracoid shaft reaches to the base of the cartilage postero-inferiorly.

Anguis D.—This was an old individual, and serves to show how little relative change takes place from the time when the Snake is only three inches long to its last condition. Fig. 6 shows the outside of the Shoulder-plates, magnified twelve diameters; and by comparing this figure with that of *Anguis A* (fig. 2), it will be seen that the changes have been principally those of bulk, and not of relative modification. The base of the supra-scapula (s. sc.) is affected by the three scapular bony rays, but the rest is quite soft. The scapula itself (sc.) is surrounded by clear cartilage; most of the præ-coracoid (p. cr.) is unossified, and so also is the outer half of the epicoracoid (e. cr.). The base of the coracoid (cr.) is extended, and the fenestra (cr. f.) is relatively less; the epicoracoid flaps overlap nearly as much as in *Anguis A*, the right overlying the left. The clavicles (cl.) have become two or three times as stout, relatively; but their shape is very little altered. The interclavicle (i. cl.) has become a single, nail-shaped bone, with a fissure through it, and a notch below its head, also showing where it was once quite divided into two pieces. It is now a good generalised representative of the so-called "ento-sternum" of the Chelonian, and "epi-sternum" of the Lizard and the Monotreme. From its position below and in front of the Sternum it stops up the chink in the latter, and appears on the inside behind the bridge of cartilage, which has cemented together the "inner coracoid lips" of the true Sternum (Plate VIII, fig. 7, i. cl., cr. g.). The Sternum (figs. 6 and 7, st.) has a greater antero-posterior diameter than in the young specimen, and there is nearly room for a first thoracoid rib behind the coracoids. The primordial division appears as a lunate notch in front and behind, and as a chink behind the confluent coracoid lips (fig. 7, st. f.); here we see the inter-clavicle fixed like a wedge in a board. The "outer coracoid lips" are more extensive than the inner (fig. 7, cr. g.), but they are both well defined; the bony patches have met and coalesced at the mid-line, and they keep very clear of the *metosteal* "inter-clavicle," showing their independence of and want of morphological relation to it.

3. "Sauria squamata typica."

A. *With three Shoulder-splints, viz. a pair of Clavicles and an "Inter-clavicle."*

I shall now undertake the description of the Shoulder-girdle and Sternum in the Lacertilia generally; excluding, at present, the Chamæleonidæ, because of the absence in them of the usual Shoulder-splints. The field, however, is so very extensive, that I cannot find either time or space for half the material at my disposal, and I must choose certain important examples which may do duty for the numberless Lacertian types. I shall very much enrich my paper by giving Rathke's account of the Breast-bone and its inter-clavicular splint (supposed by him to be the anterior sternal bone) in many species not worked out by me. The following translation (by Mr. Power) extends from page 7 to 17 of that invaluable paper. My own terms are enclosed in brackets and italics, and I shall give references to my own plates:

Rathke, '*Brustbeius der Saurier,*' pp. 7—17.

§ V.—As in the atypic Scaly Reptiles, so also in the typical Reptiles, the Sternum is usually composed of two pieces of unequal size [*Sternum and inter-clavicle*]. To this rule the Chamæleonidæ, up to the present time, constitute the only exception, for in them the bony piece [*inter-clavicle*] is absent which corresponds to the smaller sternal piece of other Scaly Reptiles. In proportion to the size of the whole body, the two sternal pieces are considerable larger in the typical Scaly Reptiles than in the atypical; and their position is so far different that in the atypical species the smaller or under piece of the Sternum [*inter-clavicle*], to a moderate or even to a considerable extent, extends in front beyond the greater piece, on which account the one may be called anterior and the other posterior.

§ VI.—The lower piece [*manubrial splint or inter-clavicle*] of the Sternum exhibits very different forms in different species of the Scaly Reptiles. In general, however, we may distinguish a central stem and two lateral prolongations. The axis of the central stem corresponds to the middle line of the body. The bone is elongated, more or less flattened above and below, and either gradually fines off into a pointed process posteriorly or retains its breadth to the extremity, which is merely rounded or blunt pointed. The stem of the anterior piece, therefore, if elongated, has some resemblance to an awl (*Varani, Lacerta agilis, Lyriocephalus margaritaceus, Agama mutabilis,* and *Oplurus torquatus*), or to the blade of a double-edged dagger (*Tejus Teguixin, Ameiva vulgaris, Iguana tuberculata, Polychrus marmoratus, Uromastix spinipes, Platydactylus guttatus*); or to the blade of a short sword (*Anolis carolinensis, Seps chalcidica, Lacerta ocellata, Basiliscus mitratus, Cyclodus nigroluteus*). It is extremely rare for it to have great breadth in proportion to its length, and the form of a table, but this occurs in *Moloch horridus* and *Phrynosoma Hàrlanii.* In the former it is an elongated triangle, the base of which is directed forwards, and is somewhat rounded. In the latter it is as long as it is broad, retains the same breadth everywhere, and behind presents a deep rectangular excavation.

The two lateral processes of the anterior sternal piece [*inter-clavicle*] either diverge from the most anterior part of the stem or from a part situated somewhat more posterior, and in both cases present variations in length and contour in different species of Scaly Reptiles. In those species in which they proceed from the most anterior part of the central piece or stem they are short, broad, and rounded at their extremities, as in *Basiliscus mitratus*; moderately long, slightly arched, and directed outwards and backwards, as in *Iguana tuberculata;* and similarly curved and directed, though longer in proportion to the stem, in *Varanus niloticus, Varanus ornatus, Varanus bivittatus, Polychrus marmoratus, Anolis carolinensis, Oplurus torquatus,* and *Phrynosoma Harlanii.* Amongst those in which the alæ or lateral pieces proceed from a portion of the stem situated further back, they are very small and only wart-like, as in *Ameiva vulgaris* and *Moloch horridus;* moderately long, remarkably broad in proportion to their length, much flattened, and altogether resembling wings, in *Tejus Teguixin, Lyriocephalus margaritaceus, Agama mutabilis, Platydactylus guttatus;* moderately long and broad, or rather small, resembling a bean, and directed outwards, in *Lac. agilis, L. ocellata, Uromastix spinipes, Seps chalcidica,* and in *Cyclodus nigroluteus.* The anterior extremity of the stem, which forms a point in the latter species, projects beyond the alæ only very slightly in *Uromastix spinipes* and *Lac. ocellata,* but considerably, on the other hand, in *Lyriocephalus margaritaceus* and *Cyclodeus nigroluteus.* The stem of the anterior sternal piece [*inter-clavicle*] reaches to a greater or less extent further backward under the posterior sternal piece [*true Sternum*], and the extent to which this occurs is in proportion to the comparative lengths of the two pieces, and is also influenced by the extent to which the anterior piece projects forwards in relation to its length. Thus in *Phrynosoma Harlanii, Moloch horridus, Calotes pictus, Lyriocephalus margaritaceus,* and *Oplurus torquatus,* it does not reach the second fourth; in *Lacerta ocellata, Lac. agilis, Basiliscus mitratus,* and *Platydactylus guttatus,* it reaches about to the middle; in *Anolis carolinensis* and *Seps chalcidica,* far beyond the middle; and in *Tejus Teguixin, Ameiva vulgaris,* and *Uromastix spinipes,* it reaches nearly the end of the plate of bone formed by the posterior [*or true*] sternal piece.

That portion of the anterior sternal piece which lies under the posterior portion is received into a corresponding fissure of the latter bone, which fissure, whilst it is for the most part only small, is yet sometimes, as in the Varanians, the Iguanians, in *Tejus Teguixin,* and *Cyclodus nigroluteus,* of considerable depth. It is usually fixed in this position by fibrous membrane, which can only be regarded as a portion of the periosteum of the posterior sternal piece; for while the furrow exists on this piece, the periosteum, as may best be perceived on making a transverse section, splits into two layers of unequal thickness, of which one invests the prolongation of the anterior sternal bone [*inter-clavicle*] on its under side, whilst the other, much thinner, surrounds it on its upper surface. But in a few Scaly Reptiles, as in *Platydactylus guttatus* and *Phrynosoma Harlanii,* the two sternal bones [*Sternum and splint*] are, after complete development, no longer connected with one another by fibrous tissue, but have actually to a greater or less extent coalesced. The substance of the anterior sternal bone [*inter-clavicle*] is in the typical as in the atypical species of Scaly Reptiles composed of strong and hard bone [*hard very early, being an ossification of fibrous tissue, "parostosis"*], the corpuscles of which are provided with numerous canaliculi containing only a simple and proportionately small cavity, and lie close to one another. They are not arranged in groups of any determinate form, but lie scattered irregularly in every part.

§ VII.—The upper or posterior and greater piece of the Sternum [*true Sternum*] in the typical Scaly Reptiles has not only a proportionately greater extent, but also a more compound form than in the atypical species, for it is provided at its extremity either with an azygous process [*meso-xiphisternum*], or with a pair of processes [*xiphisternals*], which are connected to it by a fine fibrous tissue, and very rarely, as in *Polychrus marmoratus,* coalesce with it [*they are seldom quite segmented off, and when continuous are so primordially*]. We may, therefore, differentiate two portions in this piece, an anterior and a posterior, of which the former constitutes the most essential part of the whole Sternum.

The anterior division, or the body of the posterior sternal bone [*præ-mesosternum*] is a moderately thick shield-like plate, which is slightly concave on its upper aspect, or the surface turned towards the abdominal cavity, and slightly convex on its lower surface. Sometimes, but exceedingly rarely, as in *Phrynosoma Harlanii,* it is flat on both surfaces. It usually resembles a lozenge in form, with one angle directed forward and another backward (see Plate IX, st.). It is somewhat longer than broad. The anterior angle is rather rounded, and the posterior so truncated that the bone presents at its extremities a transverse though certainly only a short border. In those Scaly Reptiles, however, in which the body possesses great breadth in proportion to its length, which is very common, the shield-like plate of the Sternum also attains great breadth, especially in its posterior half. The otherwise only short posterior border is then of considerable length, and the whole plate presents a general resemblance to a pentagon with equal sides. A strong approximation to such a form occurs in *Agama umbra, Basiliscus mitratus, Stellio vulgaris* (see Plate XI, fig. 2), and *Grammatophora barbata,* yet even in these the posterior border is not so large as the two postero-lateral borders.

In *Phrynosoma Harlanii,* in which the length and greatest breadth are equal, and in *Moloch horridus,* in which the greatest breadth is to the length as 1·23 to 1, they have tolerably exactly the form of an equilateral pentagon. Whatever, however, may be their form, their antero-lateral borders are in relation to the hooked collar-bones [*the coracoids*], and their postero-lateral edges with some of the ribs.

In the typical Scaly Reptiles the shield-like plate of the posterior sternal bone is usually a little thinner towards the middle than at its edges. In several of these Reptiles it is actually perforated, presenting a space in the centre (Plate IX, figs. 3, 5, and 6), which is closed up by the periosteum of the Sternum extended over it. A similar space or fontanelle of very moderate size and rounded form is apparent at a short distance from the end of the bone in *Lacerta ocellata* and *Seps chalcidica;* a much larger one of roundish form in the middle of the bone in *Lophyrus giganteus;* one of considerable size, but of a large oval form, with the long diameter in the axis of the body, in *Ameiva vulgaris, Iguana tuberculata* (see Plate IX, figs. 5 and 6), *Lacerta agilis, Oplurus torquatus, Agama umbra, Ag. colonorum, Phrynosoma Harlanii, Phrynocephalus caudivolvus,* and *Calotes pictus* (Cuv., *Agama picta,* Pr. Max). If these spaces be not far back, but near the middle of the bone, they are in some cases completely, in others incompletely, covered on the under surface by the anterior sternal bone [*inter-clavicle*], according as this stem has a greater or less length and breadth (see Plate IX, fig. 2). In other cases, again, the anterior sternal bone does not reach to them nor in any way cover them, which is especially seen in *Lacerta agilis, Calotes pictus, Oplurus torquatus,* and *Seps chalcidica.* Sometimes, though rarely, two such spaces appear in the shield-like plate, lying symmetrically, and separated by a small process of bone in the middle line.

Cases of this kind are presented by *Stellio vulgaris* (see Plate XI, fig. 2) and *Agama mutabilis,* in which the spaces are of moderate size and of a long oval form, with the broader end directed forwards. In *Uromastix spinipes* the number of spaces is still greater, three lying close together, the two lateral spaces [*ento-mesosternal clefts*] of a long oval form, with their broad ends turned forward and of moderate size; the middle one [*primordial cleft or "fontanelle"*] is, indeed, longer, but much smaller, elongated, and triangular, with its basis directed forwards, and completely covered on its under surface by the stem of the anterior sternal bone [*inter-clavicle*].

§ VIII. According to the statement of Cuvier, in animals of the Monitor species (*Varanus*) the posterior piece of the Sternum is apparently divided by a fissure,[1] and this statement rests apparently upon Stannius's expression, that in *Varanus* the posterior piece of the sternum is formed of two symmetrical lateral halves, each of which is cartilaginous.[2] But in three examples of the genus *Varanus,* particularly in one of *V. niloticus,* one foot eight inches long, another somewhat larger of *V. ornatus,* and a third, *V. bivittatus,* two feet eight inches six lines long, I have found the plate of the posterior sternal bone which is lozenge-shaped in these Saurians, neither divided longitudinally nor perforate in the centre, yet presenting such an appearance that upon a superficial examination with the naked eye it might be concluded that it was composed of two plates of cartilage connected together by fibrous tissue. On its convex under surface, as in many other Scaly Reptiles, there may be seen a moderately broad groove, proceeding from its anterior angle, and extending to a considerable distance behind its middle. At first this is only shallow, but it becomes deeper posteriorly, and is occupied by the posterior half of the anterior sternal bone [*inter-clavicle*]. Corresponding to this groove and extending over it from behind, is a straight whitish streak (see Plate X, figs. 8 and 10), which completely passes through it from the upper to the lower side. This is small anteriorly, then gradually becomes considerably broader, and then again towards the end of the above-mentioned grooves it becomes smaller till it is no wider than in front, and, finally, terminates in the posterior angle of this lozenge-shaped piece of skeleton. If thin sections of this be now examined microscopically, it appears that the whitish streak in question is only composed of fibrous tissue at its upper and lower side, to wit, from a portion of the periosteum of the lozenge-shaped sternal plate, but in the interior it is formed of hyaline cartilage throughout its whole length and breadth; and that the greater *portions* of the plate lying on its two sides pass into it without interruption; these *portions,* however, only consist of cartilage on their surface, whilst they are bony

[1] 'Recherches sur les Oss. Foss.,' 4th edit. vol. ii, p. 84.

[2] 'Lehrbuch der verg. Anat. v. v. Siebold und Stannius,' vol. ii, p. 138.

in their interior. In other typical Scaly Reptiles, when they were adults, I have been unable to discover in the shield-like plate of the posterior sternal bone any such persistent cartilaginous streak passing through it as in *Varanus,* but they appeared to be ossified through their whole length and breadth. I have, indeed, in young specimens of *Lacerta agilis,* found that the ossification of the plate in question commences in the interior of the two lateral halves, extending partly towards the middle line, partly towards the surface. I have also in older specimens of a few other Scaly Reptiles observed these plates still unossified near the surface, being covered with a very thin superficial layer of cartilage. The bony substance of the shield-like plate, as well as the appanage of the posterior sternal plate, which appendage likewise ossifies from within outwards, is much less strong and dense than those of the anterior sternal plate [*inter-clavicle*], and exhibits a granular structure, whose granules or compound bone-cells have a diamater of 0·0040 inch in diameter, and they resemble the structure previously described as possessed by the posterior sternal plate [*præ-sternum*] of *Pseudopus Pallasii.*

§ IX. As already remarked, in most of the typical Scaly Reptiles there is to be found at the extremity of their posterior sternal bone an appendage directed backwards, which consists of one [*meso-xiphisternum*] or two [*xiphisternal horns*] bony pieces, that are movably connected with the chief bone by fibrous tissue, and are rarely continuous with it. [*The cleft is seldom quite through the cartilage.*] When two such pieces are present they appear like a couple of horns of symmetrical form and size, or nearly so. For the most part these appear somewhat flattened on their upper and lower surfaces; occasionally, as in *Draco viridis* and *Agama umbra,* cylindrical in relation to their length they have only a very moderate breadth and thickness. Posteriorly they terminate either between the muscles of the abdominal wall or attach themselves to the extremities of two corresponding ribs, in such a manner as to form an obtuse angle or a pair of arches. In the former case they narrow as they pass outwards, and terminate in a point; in the latter case they usually preserve the same breadth and thickness to their extremities.

Anteriorly, where they are attached to the plate of the posterior sternal bone, they lie in close contiguity to one another when this plate has the form of a lozenge (Plate X, fig. 10), and are only slightly supported by its posterior angle. On the other hand, they are separated by a considerable interval when the above-mentioned plate is broad posteriorly, and presents the form of a regular pentagon (Plate XI, fig. 2), their distance being, indeed, regulated by the length of this posterior side of the pentagon in proportion to that of the other sides. In their course backwards they are either parallel to one another or in the first instance diverge and then approximate, or, lastly, pursue altogether a divergent course. In the process of development the horns of the Sternal bone are also ossified from the centre towards the circumference, but a more or less thick layer of unossified cartilage may frequently be found covering the surface.

§ X. Sternal bones [*free xiphisternals*], with free extremities unattached to a pair of ribs, occur in *Draco viridis, Lophyrus giganteus, Lyriocephalus margaritaceus, Istiurus amboinensis, Basiliscus mitratus, Moloch horridus, Phrynosoma Harlanii, Phrynocephalus caudivolvus, Agama mutabilis, Ag. colonorum, Grammatophora barbata, Stellio vulgaris* (Plate XI, figs. 1 and 2), *Zonurus cordylus, Uromastix spinipes.* In all these Saurians the processes are bent outward, and are most distant from one another at their extremities; yet in the different species their curvature and relative position to one another is so far different that in some, particularly in *Draco viridis, Lophyrus giganteus, Lyriocephalus margaritaceus,* and *Zonurus cordylus,* they are for a very small extent in the first instance bent outwards, but subsequently become widely divergent, whilst in other cases they are widely divergent from the very commencement. The extremities are for the most part simply directed outwards; but in a few cases, especially in the species already adduced of the genera *Draco, Lophyrus, Lyriocephalus, Grammatophora,* and *Stellio* (Plate XI, figs. 1 and 2), the ends are hook-shaped and are bent outwards and forwards. As regards the position of the ends, they are found to terminate near the line of union of the abdominal wall and the lateral surface of the body, or somewhat higher, and in the substance of the latter.

These parts of the skeleton are in proportion to the length of the plate of the posterior [*true*] sternal bone, as well as in proportion to the length of the body, in some of the above-named Scaly Reptiles of moderate, in others of great, length. In the following table are given my measurements as obtained from specimens preserved in spirit of their length, as compared with the length of the posterior sternal bone :

In	*Zonurus cordylus*	= 0·93 : 1
,,	*Phrynosoma Harlanii*	= 1·00 : 1
,,	*Istiurus amboinensis*	= 1·33 : 1
,,	*Lophyrus giganteus*	= 1·35 : 1
,,	*Basiliscus mitratus*	= 1·50 : 1
,,	*Grammatophora barbata*	= 1·50 : 1
,,	*Phrynocephalus caudivolvus*	= 1·54 : 1
,,	*Lyriocephalus margaritaceus*	= 1·55 : 1
,,	*Agama colonorum*	= 1·55 : 1
,,	*Uromastix spinipes*	= 1·66 : 1
,,	*Moloch horridus*	= 1·77 : 1
,,	*Draco viridis*	= 1·87 : 1
,,	*Stellio vulgaris*	= 2·25 : 1
,,	*Agama mutabilis*	= 2·27 : 1.

§ XI.—If the horns of the Sternal bone in typical examples of the Scaly Reptiles have united [*are connate*] at their extremities with the ends of two ribs (see Plate IX), they are either connected together by a thin layer of fibrous tissue or the osseous and cartilaginous tissues of the two bones coalesce. The former condition occurs in *Varanus ornatus, Varanus bivittatus, Tejus Teguixin, Lacerta ocellata, Lacerta agilis, Platydactylus guttatus, Platydactylus ægyptius,* and *Iguana tuberculata* (Plate IX, figs. 4 and 5); the latter (see Plate X, figs. 8 and 10) is present in *Varanus niloticus, Anolis carolinensis, Oplurus torquatus, Agama umbra*[1], *Cyclodus nigroluteus, Polychrus marmoratus,* and *Seps chalcidica* [see Plate X, fig. 2; but in my specimen of *Cyclodus* there is union of the two horns to form a *meso-sternal* piece. W.K.P.]

Amongst those Scaly Reptiles in which the latter of the two conditions obtains there are a few in which there is scarcely any line of division between the horns of the Sternal bone and the ribs united with their extremities. This is observed in *Varanus niloticus, Seps chalcidica,* and *Anolis carolinensis* [and in *Psammosaurus scincus* and *Monitor dracæna;* see Plate X, figs. 8 and 10]; but in others there is a line at the point of union, and it is here also thinner than elsewhere. In others a similar indented line is observable at a short distance from the Sternal plate, indicating the junction of the sternal bone with the horn.

The Sternal horns, thus united [*connate, generally*] at their extremities with two ribs, are in some of the Scaly Reptiles rectilinear and parallel to one another—*Varanus ornatus* and *Varanus bivittatus* (see Plate X, fig. 10); or diverge moderately from one another—*Anolis carolinensis, Iguana tuberculata* (Plate IX, fig. 3), *Calotes pictus, Polychrus marmoratus,* and *Seps chalcidica;* and with the two ribs with which they are united form more or less convex arches. In others they, in the first

[1] It is remarkable that in *Agama umbra* the sternal horns are united at their ends to a pair of ribs, although in other species of the genus *Agama* they terminate between the muscles.

instance, diverge from one another, then again closely approximate, and form either a pair of flat arches or a pair of very obtuse angles, leaving an elongated space between them, which is broadest about its middle, and has the form of an ellipsoid, or of a lozenge, or of a moderately broad fissure. This space is occupied by a layer of fibrous tissue.

They present such a course and form in *Tejus Teguixin, Lacerta agilis, Lacerta ocellata, Platydactylus guttatus, Platyd. ægyptiacus, Euprepis Merremii,* and *Euprepis bistriatus,* in all of which, moreover, they are at their extremities united at angles of varying degrees of obliquity with one pair of ribs, their extremities being turned towards the middle line of the body. In others, again, as in *Varanus niloticus* and *Agama umbra,* they are deflected outwards, separate more and more from one another, and form with one pair of ribs well-marked arches.

In the Saurians mentioned in this paragraph, in which the length of the sternal horns were determined with perfect or nearly perfect accuracy, they were for the most part smaller than in those mentioned above; but in the several species their length was to the length of the sternal plate—

In *Varanus ornatus*	=	0·18 : 1
„ *Varanus bivittatus*	=	0·22 : 1
„ *Lacerta agilis*	=	0·57 (to 0·75) : 1
„ *Tejus Teguixin*	=	0·61 : 1
„ *Calotes pictus*	=	0·65 : 1
„ *Lacerta ocellata*	=	0·66 : 1
„ *Platydactylus ægyptiacus*	=	0·71 : 1
„ *Euprepis bistriatus*	=	0·71 : 1
„ *Agama umbra*	=	0·80 : 1
„ *Iguana tuberculata*	=	0·87 : 1
„ *Polychrus marmoratus*	=	1·00 : 1
„ *Cyclodus nigroluteus*	=	1·00 : 1
„ *Platydactylus guttatus*	=	1·12 : 1
„ *Euprepis Merremii*	=	1·14 : 1

§ XII.—An asymmetrical appendage [*xiphisternum*] to the posterior sternal bone [*meso-sternum*] appears, from the foregoing observations, to occur in a much smaller number of Scaly Lizards than a pair of symmetrical appendages. I have remarked the former only in *Gongylus ocellatus, Ameiva vulgaris,* and *Chamæsaura anguina.* In all three it consists of a bony plate, which on one side is curved upwards and on the other downwards. In *Gongylus ocellatus* this plate has the form of an elongated lozenge; but the edges were moderately concave, and the extremities somewhat truncated. Their length is proportionate to that of the posterior sternal bone [*meso-sternum*], to the end of which it was fastened, as 0·74 : 1. In *Ameiva vulgaris* it has the form of a pentagon, with an angle directed forwards, whilst the two angles that were directed backwards were prolonged into two short horns, that were connected with the ends of two ribs by a short band of connective tissue.

Including these horns, the proportion in length of this piece to the anterior division of the posterior sternal bone was as 0·82 : 1.

In *Chamæsaura anguina* it was about as long as the posterior sternal bone, and was *not,* as in the preceding animals, connected with it through fibrous tissue, but was so coalesced with it that it appeared only as a prolongation of that bone. Their anterior and posterior halves formed two triangles with concave borders, whose anterior angle (Scheitelwinkel) is turned forwards, and the remaining angles are connected with a corresponding number of ribs. In the middle of the anterior half I found a small roundish space filled with fibrous tissue.

In regard to the development of this unsymmetrical appendage to the Sternum of some of the Scaly Reptiles, we may presume that in these instances a symmetrical portion of the Sternum, the moieties of which in these Scaly Reptiles remain separate and form two moderately or considerably prolonged horns, here in an exceptional manner lie close together, and ultimately coalesce. That this is the mode of development is indicated alike by the spaces in *Chamæsaura anguina* and the two short horns in *Ameiva vulgaris,* and also the circumstance that in one of three specimens of *Cyclodus nigroluteus* [see the figures of this and of *Trachydosaurus,* Plate X, figs. 2 and 4], I found, as usual, the horns of the Sternum were of moderate length, and divided in their whole extent; in a second they had completely coalesced at their extremities, and in a third for a moderately long extent in the middle.

These last remarks of Rathke show how profound his conceptions were on these subjects. They are perfectly true to nature; and I hope, with the help of my figures, to illustrate these important researches of his, to throw still more light upon the matter, and to give to this branch of morphology an organic unity. If my descriptions are found in any case to differ from his, it will often be explicable from the fact of the great variation to be seen even in the same species, as his description of the Sternum of the three individuals of *Cyclodus nigroluteus* testifies. But the description of the Sternum and of its *interclavicular splint* forms only part of the plan of this Memoir, for I have also to give an account of the Shoulder-girdle, and of the symmetrical splints (*clavicles*) that are strapped upon it.

Example 1.—*Iguana tuberculata,* Laurenti.

In giving instances of the structure of the Shoulder of the typical Lacertilia, I need not follow any very strict zoological system, but may take them as they best come in for illustration.

The common *Iguana* possesses the most perfect Shoulder-plates, so that it may come first, and be used as a measure for the rest, and the large amount of *arrested cleavage* each plate has undergone makes it a most instructive example. These plates are, as it were, hacked into large holes (fenestræ), but there is no perfect cleft through the large osseo-cartilaginous plate. Each moiety of the Shoulder-girdle is ready to become a whole series of phalangoid rays, but there are here, as in the Reptilia generally, only two perfect shaft-bones, and no part of the plate is quite divided; we therefore miss the supra-scapular outer plate, and also that of the præ-coracoid; these regions are mostly affected by "endostosis," and this is arrested so as to leave a selvedge of clear cartilage. Plate IX, fig. 1, shows a side view of the lower part of the Iguana's thorax, of the natural size; and fig. 2 represents the same as seen from below. The supra-scapula (s. sc.) is obliquely fan-shaped; it is large, and has a five-fingered endosteal plate within, which keeps quite clear of the scapula below, does not reach the front margin, but does extend to the arcuate hinder edge. There is no indication of cleaving in the supra-scapula, save the lobulate manner in which the bony layers pass upwards into the broad part; but the rest of the Shoulder-plate is perforated with large open spaces, or "fenestræ." The longer axes of these oval windows are arranged in a fan-like manner; the upper looking upwards and forwards, the two lower downwards and forwards, whilst the top but one is directed horizontally. The lowest space is the smallest; the uppermost next; next to that comes the top but one, and the lowest but one is the largest.

The longer axis shows the direction of the splitting of the cartilaginous plate, which fission stopped short at each end, but spread laterally. These fenestræ, from below downwards, may be called the *scapular* (figs. 1 and 2, sc. f.), the *coraco-scapular* (c. s. f.), the *upper coracoid*

(u. c. f.), and the *lower coracoid* (l. c. f.). The scapular shaft-bone (sc., m. sc.) does not reach the supra-scapular bone-substance above, nor the front margin of its own cartilage; but it joins the coracoidal shaft by a fine suture which runs obliquely across the fundus of the glenoid cup. This well-ossified part of the scapula is an obliquely placed, stout, forked ray; it leans forwards, and the smaller front bar is almost horizontal: this lesser bar is the "acromion," or "meso-scapula" (m. sc.), and the space between it and the main scapula is the "scapular fenestra" (sc. f.)[1]

The anterior part of the supra-scapula, below, is not ossified; it bulges, and then, suddenly narrowing, becomes the præ-scapular belt (p. sc.). This belt widens in front of the meso-scapula, and passes continuously into the præ-coracoid (p. cr.); it has undergone endostosis in the hinder part of its lower half, and it forms the anterior boundary of the "coraco-scapular fenestra" (c. s. f.); the lower margin of this fenestra is formed by a bar of the coracoid. This latter bone (cr.) is surrounded in front and below by feebly ossified cartilage, the ossified part of the cartilage forming a præ-epicoracoid hook of bone (p. cr., e. cr.); the marginal part of the cartilage, for a considerable extent, is persistently soft. The coracoid shaft-bone is not a little remarkable; it is three-rayed, stout, broad, and has each fork dilated at the end, and impinging upon the feebly ossified rim. Its head articulates with the head of the scapula, and the hinder half of this transverse suture lies in the glenoid cup. As the two rays of the scapula turn upwards and forwards, so the three rays of the coracoid turn downwards and forwards; and thus these five rays spread, fan-like, forwards, separated by the large arrested clefts, and hedged in by the partially ossified cartilage in front and below. If these horizontal clefts had been perfect, the Shoulder-girdle plate of the Iguana would have formed five sub-parallel rays like the brachial series of the Osseous Fish; if vertical cleavage had taken place, obscurely indicated, *histologically*, by the arrest of the diaphysial bars, and by the subdivision of the feeble, internal bone, then there would have been a double series, as in the limb of the Herring and the Polypterus; and this in the fixed root of the limb, and not in the free part. When I come to the Warm-blooded Classes I shall show how large an amount of segmentation this marginal præ-coraco-scapular band undergoes; but we shall always find the stronger posterior part of the Shoulder-plate very much indisposed to segmentation. I call the main bar of the coracoid simply the coracoid (cr.); the upper bar is the root of the præ-coracoid, the rest of which is but little ossified; and then the second spur of the diaphysis runs down the meso-coracoid region (m. cr.); this shorter bar and the main bone are bordered by the epicoracoid (e. cr.). In the head of the bone, in front of the glenoid excavation, is seen the usual nerve-passage; below, the left epicoracoid is seen (Plate IX, fig. 2, e. cr.) to *underlie* the right.

But these large many-windowed plates do not form the whole of the Iguana's Shoulder; they are strongly and elegantly undergirt with bones of an entirely opposite nature, which differ from the endo-skeletal arch as the scaffolding differs from a building. In the Lizards generally, with their expansible chests, there are but three of these outer, subcutaneous bars; but we shall find a much greater number in the box-chested Reptiles (Chelonia), where we may say that the Ganoid Fish reappears, not much happier with his higher powers, in the phlegmatic Tortoise. Plate IX, figs. 1 and 2, cl., i. cl.) show these splint-bones in the Iguana; the symmetrical pieces are the clavicles,

[1] This fissure takes place at the opposite end of the scapula to what we find in the Batrachia, where it is basal, and runs into the glenoid cavity.

and the azygous piece the inter-clavicle. The former are strong, gently arcuate rods, loosely attached to the front of the Shoulder-girdle, and reaching from the base of the supra-scapula to the part where the præ-coracoid bends backwards to become the epicoracoid. They meet (see fig. 2, cl.) in front of and a little above the inter-clavicle (i. cl.), to the transverse bars of which they are strongly fastened. Fig. 2 shows that they lie in a plane *outside* the Shoulder-girdle; and this position is more clearly seen as it regards the azygous bone (i. cl.). This bone, the inter-clavicle, is a miniature dagger,—a bony "dagger of lath;" for it is a very fibrous bone, although strong enough withal. Above and below (figs. 2 and 3, i. cl.), it has an ornamental knob in front, and from these knobs proceed a pair of gently curved bars, which look backwards, anchor-like. The main, or longitudinal bar, reaches to twice the extent of the sub-transverse bars; it is narrow at first, but its posterior half is like a surgeon's lancet, in outline; it is concave above and convex below. More than a third of this bar underlies the Sternum (see fig. 2).

Most authors have seen the counterparts of the human clavicles in the symmetrical splints, but the azygous piece has been misunderstood entirely; these clavicles, however, are *pure*, and not mixed up at their extremities with any endo-skeletal part, as in Man and many other Warm-blooded Vertebrates. The azygous piece, my "inter-clavicle," is the "episternum" of most authors; but it has nothing in common with the so-called "episternum" of the Frog—my "omosternum;" nor with the *cervical*, projecting portion of the Mammalian manubrium. In relation to the thorax generally, these bars or plates may be called the "præ-thoracic" and "ento-thoracic" derm-plates; the latter shows its nature well in the five-rayed form, which will remind the least observant anatomist of the plastron-plates of the Tortoise. This is the true homology of these three splints; they do correspond to the three anterior plastron-bones of the Chelonian.

The Sternum of the Iguana (Plate IX, figs. 1—3, st.), in the main part, is lozenge-shaped; it is slightly concave above (fig. 3) and convex below (figs. 1 and 2); it is rather wanting in bilateral symmetry.

The antero-lateral margins are grooved for the coracoids; the groove is rather deep (see fig. 6, which shows this part of the Sternum in section, with its two endosteal layers of bone, magnified twelve diameters), and the lower lip of this groove (fig. 3, l. c. l.) is jagged anteriorly.

The postero-lateral margins have elevated synovial facets for four pairs of sternal ribs; and a line drawn across in front of the second pair would separate the manubrium from the meso-sternum: there is no sign of separation into segments, save the concavities between the synovial facets. At the junction of the præ-sternal and meso-sternal regions, there is along the mid-line an oval "fontanelle," or "primordial fenestra:" the blade of the inter-clavicle does not nearly reach this open space. The ossification of the main Sternal-plate has taken place by symmetrical endosteal deposits, but these have united at the mid-line to a considerable degree; the lower layer to much the greatest extent (see fig. 2), the upper by an isthmus behind the fontanelle (fig. 3). Besides the unossified cartilage at the mid-line, all the margin continues soft, even in old age. Fig. 4 shows a section magnified twelve diameters, made transversely near the end of the Sternum; it cuts through the upper isthmus, but finds a gap in the lower layer of bone. Between the fourth pair of ribs there are two much thicker bars, which are not segmented off from the Sternum, but only suffer constriction where they join it; these are the xiphisternal horns. These "horns" bifurcate at about the distance of nine lines from the Sternum, and these forks are seen to be the fifth and sixth sternal ribs. This *connation* is a matter of arrested development, which, if perfect, would have made two more meso-sternal regions with the two pairs of ribs articulated to these parts as their own proper key-bones: instances yet to be given will explain this. Fig. 5 shows one of these bars in section, magnified twelve diameters, with its perichondrium, hyaline cartilage, and endosteal ring, enclosing, here and there, islets of cartilage. Before the sternal ribs reach the fully ossified vertebral ribs, a great constriction is observed; this arises from the partial segmentation of what I propose to call the "intermediate rib:" it is better seen in some other types to be hereafter described.

The first thoracic rib belongs to the seventh vertebra; the last cervical rib is free, and is ten lines long; the penultimate is six lines in length, but the other four cervical vertebræ have no distinct ribs.[1]

Example 2.—*Læmanctus longipes*, Wiegmann.

This very beautiful Mexican Lizard has a simpler Shoulder-girdle than the Iguana; this will be seen by comparing the figures in Plate IX: those of *Læmanctus* (figs. 7—9) are magnified three diameters, so as to appear equal to their counterparts in the Iguana.

The supra-scapula (fig. 7, s. sc.) is more symmetrically fan-shaped than in the Iguana, and it has at least seven lobes to its endosteal layer: this gives it the appearance of a Cock's comb. The high scapula (sc.) is almost entirely covered by ectosteal bone; there is, however, a small epiphysis on the front of the meso-scapula: this is hidden, in the figure, by the clavicle (cl.). There is a shallow scapular notch (sc. n.) dividing the main part from the meso-scapula (m. sc.); but this was much deeper originally, before the growth of the periosteal layers of bone, indicated in the figure by a shaded groove. The coraco-scapular fenestra of the Iguana is here represented by a notch (c. s. n.); this is large and deep, and depends upon the complete fission of the plate anteriorly, as in the upper notch. The coracoid (cr.) is a broad ray, convex on the outside, and very much scooped within, where the meso-coracoid margin is seen to be much thickened, but to be not otherwise differentiated. A suture can be seen in front of the glenoid cup (gl.), and below it a nerve-passage, which is double on the right side (fig. 8): in front of this canal is the large elliptical, down-turned coracoid fenestra, the space so familiar to us in the Batrachia. The lesser fork of the coracoid ossifies more than half of the præ-coracoid bar (p. cr.), which has no differentiation from the epicoracoid (e. cr.) save the acute angle at which it becomes continuous with that semi-osseous headland of the coracoid: the right and left flaps overlap each other to some extent.

The antero-lateral margins of the Sternum (st.) are only three fifths the length of the postero-lateral, and not equal, as in the Iguana; the former are thickened considerably both below (fig. 8) and above (fig. 9); this latter figure shows that the lower lips (l. c. l.) project further forwards than the upper (u. c. l.), which unite at a rather obtuse angle, and have within that angle two swollen hillocks of cartilage, which abruptly bound the great sternal fontanelle anteriorly. This thickening, and the gap behind it, will often turn up again in the Bird-class; here the primordial cleft is seen to be occupied by the hinder part of the "inter-clavicle" (i. cl.), which

[1] In Plate IX, fig. 1, the Shoulder-plate is shown leaning forwards from the first rib, further than what is found in nature; this has been done for the sake of displaying the parts; the great plate itself stands too erect in the figure, but it was necessary to give the actual and relative size of the bars and fenestræ.

thickens from below upwards to stop this gap in the Sternum. The four anterior cervical vertebræ of *Læmanctus* have no free ribs; the next two have each a pair of floating ribs, tipped with cartilage, and three or four lines in length. The seventh and eighth have ribs equal to those of the dorsal region, namely, seven lines long, and well ossified, with a small triangular epiphysis at the end; and these turn towards each other, below (fig. 7, c. 7, c. 8): the ninth vertebra is the first dorsal. Four pairs of dorsal ribs have semi-osseous sternal portions which articulate by perfect (synovial) joints with the long sides of the Sternum.[1] The narrow posterior end of the Sternum is entirely occupied with the large xiphisternal horns (x. st.), the broad single portion of which is three lines in extent; the forks into which these break are the fifth and sixth sternal ribs (fig. 7): these have no "costa intermedia" constricted from them, nor have the preceding four. The sternal horns are continuous with the meso-sternum, but there has been an attempt at segmentation in the form of a lateral vertical groove (fig. 7, st. x. st.), and there is a clear space of unossified cartilage between the endosteal deposits. In the præ-meso-sternum clear cartilage is seen marginally, round the fontanelle above, and also near the "horns" (fig. 9) below; the lower internal bony plate is quite divided into two equal halves (fig. 8). The sternal ribs, like the xiphisternal horns, are composed of a tube of soft cartilage, having in it a tube of bone; and lastly, an axial pith of soft cartilage; this, however, is common to the Lacertilia. The clavicles (cl.) of *Læmanctus* are elegant *f*-shaped bars, narrow and pointed where they join the base of the supra-scapula, and expanded below: in the expanded part there is an open membranous space (figs. 7 and 8). The "inter-clavicle" (i. cl.) is a long, very elegant, cross-shaped bone, the transverse bars of which are three lines in extent, and the longitudinal part nine lines long. The lower surface of the bone projects, anteriorly, as a crescentic ridge bounding the groove in which the clavicles lie, but do not quite meet (fig. 8); above (fig. 9), there is a rounded ridge, with a blunt end: the transverse bars are also knobbed at their ends, and they turn a little backwards. Behind these bars the main part is constricted; it then widens gradually to the middle, and as gradually becomes attenuated to a blunt point (fig. 8). It is flat above (fig. 9), convex below (fig. 8), and becomes thickened, vertically, where it shuts up the sternal fontanelle (fig. 9, i. cl.). This is the longest "inter-clavicle" I have to describe, for it reaches to between the second pair of ribs: in *Monitor dracæna* it is very long, but only reaches to between the first pair. We shall see the inter-clavicle wedging itself between the sternal moieties again in the Grallæ amongst the Birds (*e. g. Grus montignesia*, Plate XIV., figs. 6 and 7). In ascending from Class to Class we are never safe from the repetition of some morphological *habit*, which, being the *rule* in the lower types, characterises them, but recurs exceptionally higher up. This *affinity* of the posterior part of the inter-clavicle for the divisional line of the Sternum may be said to be a Reptilian character; but whenever this part is sufficiently developed in Birds we then find that it recurs.

Example 3.—*Cyclodus nigroluteus,* Quoy and Gaimard.

The mailed Cyclodonts yield examples of Shoulder-girdle and Sternum no less instructive than those of the Iguanians; and they especially serve to show what becomes of the pair of forked xiphisternals in the next metamorphic stage to that last described. Plate X, figs. 1 and 2, show

[1] Fig. 8 does not show the left side of the Sternum so *short* as it ought to have done; Fig. 9 shows it better.

these parts in *Cyclodus nigroluteus*, magnified one and a half diameter. The large fan-shaped supra-scapula (fig. 1, sc.) is everywhere affected by endostosis; and there is no distinction between the bony core of the scapula and the supra-scapular bone-substance; this ossification also runs continuously down the marginal bar (p. sc.); and the lower cartilage (p. cr.) is similarly ossified; so that the præ-scapula, præ-coracoid, and epicoracoid, together form one half-bony band of considerable breadth, especially below (see figs. 1 and 2, p. sc., p. cr., e. cr.). The heads of the scapula (sc.) and coracoid (cr.) unite by suture, and at some distance below this suture is seen the nerve-passage. As in the Iguana, the scapula is bifurcate above, the space between the forks being the "scapular fenestra" (sc. f.); this is less than in the Iguana, and the forks are more nearly equal: the lower fork, which runs upwards and forwards, is the meso-scapula or "acromion" (m. sc). Below the meso-scapula is the coraco-scapular *notch*—not fenestra; and this is bounded below by the root of the præ-coracoid (p. cr.): the coracoid itself (cr.) is only bifurcate, and has a long fenestra (cr. f.): the epicoracoids (e. cr.) are very large, and overlap each other (fig. 2, e. cr.); they nearly rival those of the Urodelous Amphibia. The splint-bones (cl., i. cl.) are relatively very large; they are much more splintery and lath-like than is usual in the Lacertilia, and the clavicles (cl.) are peculiarly ichthyic. The cross-shaped inter-clavicle (fig. 2, i. cl.) must be compared with the plastron-bones of the Chelonians (Plate XII); it is four-rayed, and the transverse rays are slightly deflected, and are nearly equal to the fore-and-aft portions of the main or longitudinal part. This latter part, both before and behind, is lancet-shaped, but the points are blunt: the great transverse extension of the inter-clavicle is a correlate of the expansion of the epicoracoids.

The Sternum (st.) in its main part is lozenge-shaped; the four oblique sides being nearly equal; it is very flat, rather thin, and is continuous behind with the smaller piece: a constriction, however, shows that transverse segmentation did commence, but was arrested. A primordial notch (hidden in fig. 2 by the inter-clavicle) separates the deeply grooved coraco-sternal regions (see this groove in fig. 1, st.). The left moiety is larger than the right (fig. 2), and these regions are much thicker than the rest of the Sternum. Three pairs of ribs articulate by perfect joints with the postero-lateral margins, so that in the main piece we have the manubrium and the next two sternal pieces in a connate condition; but the interspaces between the articular eminences are well notched, showing a readiness for transverse cleavage of the continuous sternal mass. The first pair of perfect ribs belong to the ninth vertebra; the seventh and eighth cervicals have ribs equal in size to the vertebral part of the first dorsal; three vertebræ in front of these have small free ribs, but the three foremost cervicals have no free ribs. The bifurcate xiphisternals, such as we saw in the Iguana, have in this case undergone a further metamorphosis, and they are now *xiphi*sternal no longer, but *meso*sternal. Being primarily in close apposition at the mid-line—save at their middle, the inner edges of these "horns" have coalesced, all except a fourth part, which part lies nearly between the fourth pair of thoracic ribs; this unclosed space is seen as a tear-shaped "fontanelle" (fig. 2, st. f.). The fourth and fifth sternal ribs, with which this part of the Sternum was continuous, have become nearly segmented off by transverse cleavage (fig. 2); but there is a continuous pith of cartilage not severed in this growth-process, as also there is between the two divisions of the Sternum. The fourth sternal rib (s. r. 4) is much urther from the mid-line than the fifth, for the additional sternal piece is widest where this rib runs into it; and it is also twice as far from the third rib as that is from the second: the fourth and fifth are at the normal distance. This unusual space between the third and fourth ribs, and the incompleteness of the segmentation between the new key-stone and the pier of the fourth and fifth costal arches, are very delicate measurements of the degree of metamorphosis of these parts: all these parts, namely, Sternum and sternal ribs, are ossified endosteally, and the Sternum itself by symmetrical halves (see fig. 2). Plate X, fig. 6, shows a section through the lower part of the coracoid magnified ten diameters; the double layer of endosteal bone (en. o.) in the epicoracoid (e. cr.) is well shown.

Example 4.—*Trachydosaurus rugosus*, Gray.

This great Australian Lizard is perhaps still more instructive than its relative just described. In this species the supra-scapula (Plate X, fig. 3, s. sc.) is smaller in proportion to the scapular shaft (sc.) than in the last; and this latter bone is but little cleft above: the cleft, however, is evident, and shows what a fenestra is at its first appearance. The broad, badly defined meso-scapula (acromion) is bordered by a narrow band of soft cartilage (fig. 3, p. sc.), so that there is here less continuity of the internal bone than in *Cyclodus;* also the crest of the supra-scapula is soft (fig. 3). The coraco-scapular notch (fig. 3) is smaller, and therefore we have here a very wide neck to the scapula, and the oblique suture connecting it with the coracoid is very long. This latter bone (cr.) is very broad, and is only bifurcate, so that in this case also there is only one coracoid fenestra; this a long ellipse (see fig. 5, c. f.). The epicoracoids (fig. 5, e. cr.) are nearly as large, relatively, as those of a Salamander; and, as in that creature, there seems to be some variation in the overlapping of these flaps, for—as fig. 5 shows—the left *overlies* the right; contrary to what I have shown in the Iguana (Plate IX, fig. 2).

The homologies of the Shoulder-splints in *Trachydosaurus* appear to me to be self-evident; for this creature has positively retained the very self-same kind of clavicles as those possessed by the ordinary Osseous Fish. Were the supra-scapula absent, as in the Teleostei, and the rest of the Shoulder-girdle moiety relatively somewhat smaller, then surely even a transcendentalist would acknowledge the unity of the clavicles here figured (Plate X, figs. 3—5, cl.), and those of an ordinary Bony Fish. In fig. 3 it is shown that the clavicle passes above the scapula, and that it broadens out below into a large convexo-concave plate, which is applied, like a pasteboard splint, to the front and outside of the Shoulder-plate. Fig. 5 shows that these clavicles have their thick front edges turned over the front of the præ-coracoid, and that the endo-skeletal parts lie folded in and embraced by these scooped exo-skeletal bones, exactly as in the Fish.

Fig. 4, displaying these bones from below, shows the not infrequent membranous space (see Plate IX, fig. 8, cl., and Plate XIII, figs. 1 and 2, cl.), and also the wild, jagged, Fish-like hinder margin of the bone. If, however, this bone is illustrated by what is seen in the lower Class, it also typifies still higher forms, and foreshadows what is seen in the embryo of the Bird. The relation of the clavicles to the inter-clavicle (fig. 4, cl., i. cl.) is perfectly Reptilian, and they are seen to correspond completely to the three foremost bones of the Chelonian plastron (see Plate XII). The inter-clavicle (fig. 4, i. cl.) has its four rays more nearly equal than in *Cyclodus;* the lateral rays, a little the smallest, are both decurved and turned upwards, and all the rays are less spatulate than in the last example: the hindermost underlies the præ-sternal notch (see figs. 4 and 5).

The antero-lateral margins of the Sternum (fig. 4) are longer, by far, than the postero-lateral; this arises, from the large room required by the huge epicoracoids; the left *lower* coracoid lip is longer than the right (fig. 4); the right *upper* lip is longer than the left (fig. 5). In *Trachydosaurus rugosus* the first two cervical vertebræ are devoid of free ribs; from the third to the eighth (inclusive) there are floating ribs; fig. 3 shows the lower part of the last and penultimate cervicals; and it is seen that they are (as in *Læmanctus* and *Cyclodus*) as long as the vertebral part of the dorsal ribs. There are, as in *Cyclodus*, three pairs of sternal ribs articulated by perfect synovial joints with the vertebral ribs above, and with the large anterior moiety of the Sternum below, so that this part is a "præ-mesosternum;" and not a mere "manubrium:" two more meso-sternal regions have been added by taking in the lower part of the xiphisternal horns (figs. 3 and 4). We here have an additional help towards a proper conception of the nature of these parts, for the metamorphosis has not gone to the same extent as in the last instance, and the two moieties of the new meso-sternal piece are merely united by an isthmus at each end. Moreover, the transverse semi-segmentation is at a further distance from the mid-line, so that the structure is altogether looser and less finished than in *Cyclodus*. Nevertheless, the two diverging horns, behind, articulating with the fifth thoracic ribs, are really meso-sternal now; the notch between them is a primordial, posterior meso-sternal notch; and there is no xiphisternal left by this morphological process. The ossification of the Sternum of *Trachydosaurus* is by "endostosis;" and this is symmetrical, as in all the Lacertians. The limb-girdles themselves are only half as large in proportion to the body as in the Iguana; for these Scincoid Cyclodonts graduate, through intermediate species, to the "Atypical Squamate Saurians," namely, the Blind-worm, Glass-snake, &c. There is no semi-segmentation of the costal arches, so as to produce "costæ intermediæ."

Example 5.—*Psammosaurus scincus*, Merrem.

Plate X, figs. 7 and 8, show the Shoulder-girdle and Sternum of the Land-monitor of Egypt, the Ouaran-el-hard of the Arabs: the figures are one-eighth larger than the real objects. I shall now describe these structures in two members of the Varanian group, for they stand in sharp contrast to those last under review, and yet I shall be able to show that there is no essential difference in their morphology. The Monitors appear to me to be the noblest of the Lacertilia, and assuredly the Cyclodonts are a long way down in the group: the former may be taken as the type of their great Order; for the Crocodiles, although nearer the Mammalia, are evidently aberrant, and must be kept apart from the Lacertilia; the Chamæleons also are very aberrant from the other Lizards. The Varanians have some characters in their skull which foreshadow what is normal in the Bird-class, and this is in harmony with what is remarkable in the supra-scapula of Psammosaurus (Plate X, fig. 7, s. sc.), namely, its obliquity, so greatly in contrast with the regular, fan-like form seen in the Cyclodonts. It keeps its Lacertian character, however, in being ossified only partially, and by its own endosteal layers: it is strongly constricted at its neck, showing that it is really a ray superimposed upon the scapula, and not a mere process or crest of that bone. Amongst the proper Lacertians *Psammosaurus* is peculiar in having its scapula (sc.) entirely invested by the ectosteal layer; in this it agrees with all the Amphibia; with the two-legged Amphisbænian *Chirotes*; with the Chamæleons and Crocodiles; and with the Warm-blooded Classes generally. If we compare this scapula with that of the Iguana and the Cyclodonts, it is evident that the meso-scapula is connate with the scapula proper; if we look at the next instance (Plate X, fig. 9), it will be seen that the scapula shown in fig. 7 is altogether devoid of the præ-scapular band. It is a broad ray, somewhat curved inwards above, and receiving the supra-scapula at a right angle (fig. 8); its posterior border is thick, and its anterior border sharp, like a knife; its suture with the coracoid is curiously bent upwards in front of the glenoid cavity.

The coracoid of *Psammosaurus* (figs. 7 and 8, cr.) is of very great extent; and from the obliquity of the suture runs up in front of the scapula; contrary to what occurs in the latter bone, it has all the Lacertian fenestrate clefts. The upper fork of the three into which the shaft-bone is divided runs along one third of the præ-coracoid band (p. cr.); the middle fork, or meso-coracoid (m. cr.), is much larger, whilst the main coracoid (cr.) is a broad axe-shaped plate, having a thick semi-osseous edge. This endosteal cartilage is very broad where it forms the boundary of the lower and upper coracoid fenestræ (l. c. f., u. c. f.) and the broad end of the meso-coracoid: it narrows as it turns suddenly round to become the præ-coracoid band (Plate X, figs. 7 and 8, e. cr., p. cr.).

The large *ichthyic* Shoulder-splints of the Cyclodonts are in strong contrast with the delicate rods seen in the Varanians; figs. 7 and 8, cl., show the rather sudden bend that the clavicle takes backwards, and that its pointed upper end only reaches to the top of the scapular shaft; and fig. 8 shows that it does not meet its fellow below: altogether, the splint system has lost much of its relative potency; whilst the endo-skeletal parts are very large. All the splints are very dense and polished, and the two clavicles and the lateral arms of the inter-clavicle (i. cl.) are almost cylindrical; but the longitudinal bar of the latter broadens where it underlies the Sternum, gradually becoming attenuated again towards its blunt point (fig. 8). The anterior ray of the inter-clavicle, instead of equalling the others, as in *Trachydosaurus*, is a mere bud; and this character, combined with the retral bend of the lateral arms, gives the slender but strong inter-clavicle of this Varanian the form of an anchor. The long, lance-shaped, longitudinal bar of the inter-clavicle does not reach the same transverse line as the articulation of the first thoracic ribs.

The Sternum (figs. 7 and 8, st.) of *Psammosaurus*, is an elegant, but scarcely symmetrical rhomb or lozenge; its coraco-sternal regions are longer than its costal margins; and the right coracoid groove and lower lip proceed further backwards than the left; the outline of these lips is sinuous. There is no primordial fissure or "fontanelle," but the internal osseous deposits are distinct and symmetrical (fig. 8), a definite line of unchanged cartilage running along the middle. The interspaces of the ribs are elegantly lunate, and only three pairs join the Sternum, as in certain Birds, for instance, *Tinamus robustus* and *Tigrisoma leucolophum*. The first pair belongs to the tenth vertebra, which leaves in front nine or one more cervical vertebræ than are found in the Cyclodonts: this is another *ornithic* character in this Varanian. The third pair of thoracic ribs, however, are connected, not with the broad part of the Sternum, but with an unossified pedicle at its end: there is some constriction where the osseous matter of the Sternum ends, and also where the bony matter of the cartilaginous rods, which run into these ribs, ceases. What these rods (x. st.) are it is difficult, at first, to say; for they answer, below, to the horns into which two pairs of ribs run in the Iguana, and are to a certain extent homologous with the free "xiphisternals" of the *Stellio* Lizard. If *longitudinal* fission had taken place in these evidently generalised rods, then we should have had the counterpart of what is seen in *Stellio;* if transverse segmentation had occurred at a moderate distance from their termination in the Sternum, then there would have been a third "meso-sternal" piece added to the large plate: this joint might have had its moieties coalesced more or less, instead of being arrested where we see them, that is, free behind, and only joined in front.

For such sternal horns, where the arrest renders their character doubtful, the term "xiphisternals" may be used; the additional epithet *free* being added where, as in *Stellio,* they are further metamorphosed by being longitudinally cloven from the sternal ribs. There is a partial differentiation of the "costa intermedia" from the sternal rib, the "endostosis" being distinct, and leaving a narrow tract unossified (fig. 7, c. i., c. s.).

Example 6.—*Monitor dracæna,* Linn., sp.

My specimen (preserved in spirits) of this beautiful Varanian is fifteen inches long—six for the head and body, and nine for the tail. The figures in Plate X, 9 and 10, are magnified three diameters. The differences between this and the last make me very desirous of working out a large number of Lacertian genera; but there is not room in the present Memoir for more than I am giving; and I have taken care to display the structure of a sufficient number for the illustration of the great group itself—the Lacertilia; and, what is of still greater importance, the Vertebrata generally. The supra-scapula (fig. 9, s. sc.) is much broader and also more symmetrical than that of the last instance: it is an *axe-blade,* narrowing but little towards its *back,* here represented by the lower margin. It is too large for the scapula, to which it forms a crest, surmounting the shaft-bone beneath, and ending postero-inferiorly in a produced angle. The two internal, sub-central bony plates are surrounded entirely by a selvedge of soft cartilage; even over the scapula the ossification is arrested so as to keep it distinct from the medullary bone of that segment. The scapula (fig. 9, sc.) is in its main part like that of *Psammosaurus,* being a broad phalangoid ray, with concave sides and convex ends; the upper being the broadest, whilst the lower is oblique. This bar contains in it the "meso-sternum," or acromion; but, as in the last instance, there has been no cleavage from the main ray: contrary to the last, however, there is there a præ-scapula (fig. 9, p. sc.), and it is almost cleft from the main bar (sc.), the fenestra (c. s. f.) being long, narrow, and pointed above. The præ-scapular bar is entirely unossified, and this soft condition is continued in front of the præ-coracoid root down to the angle (less than a right angle) at which the præ-coracoid turns where it thickens, becomes semi-osseous, and passes into the epicoracoid (e. cr.). This præ-scapular bar is an anterior continuation of the unossified cartilage at the base of the supra-scapula, and it shows how that the segmentation is imperfect throughout in the Lacertilia; the cartilage, where it suffers fission, "cleaves the cleft" imperfectly, and the morphological regions for the most part are indicated by histological modifications. This coraco-scapular fenestra will turn up again in the Sloths, and in the larger Ant-eaters among the Mammalia; but the fenestra which separates the "meso-scapula" from the "post-scapula" in the Iguana and in the Cyclodonts will reappear in the Pangolins; in the Batrachia we have the lower part of this latter cleft; in the Pangolins, the middle; and in the Iguana and Cyclodonts, the upper part; in none of these is it perfect. We shall find an instance, however, of a complete cleft between the præ-scapula and the meso-post-scapula: that will turn up in the Cat-tribe, and in allied forms.

If the scapula of *Monitor dracæna* is a key to the true morphology of the Mammalian scapula, so also is its coracoid to that of the Bird; for here we have again, as in the Iguana and in *Psammosaurus,* the broad coracoid (cr.) sending forwards and downwards two broad "outgrowths" or spurs (p. cr., m. cr.), exactly the counterpart of those spurs which embrace the "middle pectoral muscle" of the Bird, just where it is attenuating into its narrow *humeral* tendon. The band of cartilage, which is continuous, in front, with these spurs in *Monitor dracæna*, is the generalised mass out of which three distinct segments are formed in the Bird. The main ray of the coracoid in this Lizard is (see fig. 9) about twice the size of each of its two secondary rays; the fenestra (u. c. f.) between the two upper rays is twice the size of that (l. c. f.) which intervenes between the "meso-coracoid" and the main piece. As in the Iguana (Plate IX, fig. 1, e. cr.) the epicoracoid is only ossified up to the antero-inferior angle of the main coracoid; and this structure throws light upon the apparently anomalous anterior position of the epicoracoid in the Monotremes; in these, the coracoid and epicoracoid are both perfect shaft-bones, and the earlier development of the coracoid proper causes a complete ossification of the postero-inferior part from the main bone.

The splint-bones are still more delicate than in the last species; they are, indeed, like spicules rather than bones. The clavicle (fig. 9, cl.) reaches a little higher than in the last, and its bend is higher up, the rounded angle of the clavicle being exactly where the arms of the inter-clavicle ends, and these arms are longer relatively in *Monitor* than in *Psammosaurus*.

The arms of the inter-clavicle (figs. 9 and 10, i. cl.) do not curve so far backwards in the the former as in the latter; and in this *Monitor* the longitudinal bar does not flatten out so much as in the African kind; it also reaches further back (see fig. 10, as compared with fig. 8).

The Sternum of *Monitor dracæna* differs in nothing important from that of *Psammosaurus*; and one description may serve for both; but the first pair of thoracic ribs belong to the ninth vertebra, and not to the tenth, as in *Psammosaurus;* also I find only two pairs of free cervical ribs in this kind of Varanian. The "costa intermedia" is more obscurely seen than in the last instance (figs. 9 and 10, i. r.); and the articular pedicle connecting the main Sternum with its horns (figs. 9 and 10, st., x. st.) is shorter; the ribs (figs. 9 and 10) are thicker, relatively, than in the Ouaran.

Example 7.—Hemidactylus ——— ?

My next illustration is from dissections of a young Gecko from Barbadoes, a little more than an inch in length, and evidently, from its softness, very young. Plate XIII, figs. 1 and 2, show the Shoulder-girdle and Sternum of this Lizard, magnified fifteen diameters, and drawn as spread out under the "compressorium;" this dissection being seen as a transparent microscopic object.

In fig. 1 the lower view is given, in fig. 2 the upper; the former best displaying the splints, the latter allowing the best sight of the cartilaginous headlands to the bony parts of the Shoulder-girdle. In this early stage the cartilaginous parts are wholly unossified, and the only bony matter seen belongs to the thin splints, and to the scapular and coracoid "ectosteal" sheaths: within these latter deposits there may be some "endosteal" bone; but if so, it had only just commenced. Even the splint-bones themselves are only partially consolidated, for I found inside them copious collections of delicate connective-tissue-cells, many of which were thin-walled sphærules.[1] So much for the *histology;* morphologically, this specimen abates not one jot

[1] At first, I mistook these cells for thin-walled or simple cartilage-cells and hence arose the error in my "Abstract" ('Zool. Proc.,' 1864, p. 341), where the true clavicle of the Lizard is confounded with the so-called clavicle of the Frog.

of interest, as compared with the instances already given; in some respects it is still more important, being the youngest Lacertian I have been able to obtain for these researches. The supra-scapula (s. sc.) may be likened to a fan, or, still better, to an axe-blade, and it is not very irregular in form; the upper margin is convex, the sides concave; these approach each other as they join the top of the narrow scapula. This bone (sc) is a flattened ray, narrowest at its middle, and broadest below; and having at its lower third a "meso-scapular" or acromial spur growing forwards, at right angles to it (m. sc.): this spur is cartilaginous at its free end, and is bounded above by the scapular and below by the coraco-scapular notch. This is the clearest prophecy concerning the "acromion" of the Mammal, especially of the Monotreme and the Cetacean, that is given forth by the Lizard group: it is a "sure word" to him who can interpret it. The unossified end of this acromion of the Gecko is exactly that morsel of cartilage which will be found cut off from its own stem and grafted upon the upper end of the clavicle in the Bird and the Mammal, a metamorphic blending of the endo- and exo-skeletal elements never (as far as I have seen) to be found in the Cold-blooded Vertebrata.

The interspace between the scapula and the coracoid is a thick wedge of clear cartilage, the bifid posterior edge of which is the glenoid cavity (gl.). Here we have another typical "coracoid;" it is typical as a Lacertian coracoid, for I know of no fuller development of this morphological region as to *mass;* in the Birds, however, although much of the anterior cartilage is absent, yet in them there will be found two perfect lines of segmentation never seen in the Lizard, namely, one between this bone and the scapula, and the other between the head of the coracoid and the præ-coracoid.

The splint-bones of *Hemidactylus* are intermediate between their typical condition in the *Iguana* and *Læmanctus*, and their aberrant flattening-out in the Cyclodonts. The curved clavicles (cl.) are typically narrow and rounded above; below the curve, however, they become flat, broad, and partly discontinuous; there is a large membranous space, like that in *Læmanctus*, but larger, and their ends are squared, nearly reach each other, and have the anterior spur of the "interclavicle" between them. The latter bone (i. cl.) makes a considerable approach to that of *Cyclodus;* but the posterior bar is much the largest; the other three are delicate and spicular, the lateral rays being twice as long as the anterior. The former are somewhat sigmoid, but on the whole are very little curved backwards, the latter ends between the clavicles. The large hinder ray is a flat sharp-edged blade, and the whole is another variety of a "dagger of lath." The hinder half of the large blade underlies the Sternum, which in the *glycerine preparation* can be clearly seen through it. In the centre of these four rays there is an elliptical membranous space, which is an indication either of a once perfect division, as in *Anguis* (Pl. VIII, fig. 2, i. cl,), or at least of some symmetrical division of this splint at an earlier stage.

The Sternum (st.) is of the typical Lacertian form, save that the costal margins are rather rounded; the coracoid margins are sinuous, and the lower lip (fig. 1) is truncated behind and pointed in front, whilst the opposite of this is the case in the upper coracoid lip (fig. 2). The coracoid edge is thick, whilst the rest of the Sternum is thin, and rather flat; it is deeply notched in front, but all the rest has become one cartilage; three pairs of ribs articulate with its sides.

The posterior sternal horns (figs. 1 and 2) are continuous with the fourth and fifth thoracic ribs; but they are not continuous with the posterior end of the Sternum, as in the Iguana; this gives us our fourth type of Lacertian Sternum, and two more remain for description. Certainly these continuous ends of two pairs of ribs are the counterparts of what is seen in the Iguana; but in that Reptile they are only partially segmented from the main part of the Sternum; they also answer to the two additional meso-sternal segments of the Cyclodonts. No Oviparous Vertebrate that I am acquainted with has perfect transverse segmentation of the Sternum, not even amongst the Birds; but in that Class there are some Families with connate sternal ribs (see Plate XI, figs. 12 and 13 which show this structure, in the *Talegalla*); it is also seen in the Cracinæ, Gallinæ proper, and in the Anserine *Palamedea*. Therefore, notwithstanding the primordial homology of these parts with the "xiphisternal horns" of the Iguana, and with the additional meso-sternal regions of the Cyclodonts, I really consider that they have, in this case, determined themselves to be merely the uncleft extremities of the fourth and fifth ribs.[1]

Example 8.—*Stellio cordylinus,* Gray.

Plate XI, figs. 1 and 2, show the Shoulder-girdle and Sternum of this Lizard magnified two and two-thirds in diameter. This very valuable instance of Lacertian structure has in its Shoulder-girdle that which will repay careful study; but its Sternum is that which makes it of most importance. The supra-scapula (fig. 1, s. sc.) is a broad, high, curved, cartilaginous crest, having a five-spurred cockscomb-like bony deposit in it; its unossified upper part overtops its body almost equally both ways, and it is very broad down to the scapula. This latter part (sc.) is wholly ossified, as in *Psammosaurus* and *Læmanctus;* but it especially agrees with the latter in having a flat meso-scapular (acromial) lobe in front (see Plate XI, fig. 1, and Plate IX, fig. 7, m. sc.); and, as in that species, there is no præ-scapula; the whole scapula is broad and flat.

The coracoid (Plate XI, figs. 1 and 2, cr.) has the same complexity as that of *Læmanctus* and of the Cyclodonts; and, as in them, the præ-coracoid (p. cr.) is quite free, being separated from the meso-scapula by the coraco-scapular notch (fig. 1, c. s. n.), which is a large semi-elliptical space. The meso-coracoid is not at all separated from the coracoid (cr.) but the head of the coracoid runs a long distance into the præ-coracoid.

The coracoid is a very broad ray, elegantly semilunar below; and the epicoracoid (e. cr.) is a well-shaped half-moon, with only the rounded anterior angle, where the præ-coracoid commences, quite soft, or free from ossific deposit; this is the part which is cloven from the rest to form the "omosternal moiety" in the Tadpole. The oblique suture between the scapula and coracoid, and the usual foramen in the head of the coracoid, are clearly seen; also the thick-edged, cartilaginous glenoid cavity. Fig. 2 shows that the epi-coracoids in this flat-bellied Lizard are kept far apart by the intrusion of the broad Sternum, a condition which is normal in Birds, where the coracoids overlap only exceptionally.

The clavicles (figs. 1 and 2, cl.) are very strong; they also meet together, not as in the Iguana (Plate IX, fig. 2), in *front* of the azygous bone, but *below* its anterior part; it is seen in fig. 2 how that the inter-clavicle is clasped and embraced by the clavicles. These stout clavicles are bluntly pointed above (fig. 1, cl.), where they touch the front of the base of the overhanging

[1] I propound this the more boldly that I may weaken the influence of the merely *regional terms* upon my own mind and that of others; for whilst there can be no description without the use of certain terms, yet, as these terms are often arbitrary, they are apt to clog the mental faculties, and hinder when they ought to help.

supra-scapula; they then suddenly widen behind, and narrow only a little downwards; they are transversely cut and toothed to form a suture, where they meet at the mid-line.

In the Chelonia (see Plate XII) the "inter-clavicle" is subject to the development of the large bony plates that surround it; it is therefore relatively rather small, for the bones in the bodies of animals are like trees in a plantation; their development depends upon the room they have for expansion, and also in some degree upon the start the older trees get upon the newer. There is something of this overshadowing in the inter-clavicle of the Chelonian; but in the Lizard the single bone has only two competitors; and, posteriorly, it is free of all the ground. Now, this is especially exemplified in *Stellio,* where the inter-clavicle is equal to one of the lateral bones in the Chelonian, and is precisely such a radiating plate. Fig. 2 shows that the anterior knob is trifid, and that the transverse bars are forked, the hinder spurs being only half the size of those in front; they both curve backwards, but the smaller forks to the greatest degree; *these* clamp the anterior part of the lower coracoid lips of the Sternum (Fig. 2, st.); *those* are tied fast to the hinder and inner edge of the clavicles below. The whole of the posterior bar of this eight-rayed inter-clavicle is applied to the under-surface of the anterior third of the Sternum; it is shaped like the blade of a dagger.

The Sternum of *Stellio* (Plate XI, fig. 2) is a forecast of what is found in the Bird; some of its most remarkable peculiarities, also, are to be seen in certain Mammals. The main part is pentagonal, the antero- and postero-lateral margins being nearly equal, whilst the posterior transverse margin is two thirds the extent of the others; the whole plate answers to the præ- and meso-sternal regions of the Mammal. The posterior angles pass into the xiphisternals (x. st.) by a constricted isthmus. Most of the sternal regions of the Bird appear in this sternal plate, namely, the coraco-, præ-, meso-, ento-, and xiphisternal regions. This is the first appearance of a mesial part (e. st.), as separated from the lateral or costal regions; and the extent to which this further subdivision is carried in the Bird shows the great importance of the study of *fenestræ* in morphology, revealing the fact that they are not in the least accidental, and are true *clefts,* although arrested at both ends. The large, sinous, double-lipped "coraco-sternal" edges (fig. 2), meet at rather more than a right angle; the Sternum is notched at the angle, and the right side projects further beyond the notch than the left. The costal margins receive three pairs of ribs, which are "thoracic;" and therefore the "præ-sternum" reaches—if compared with the like part in the Human Sternum—to the second rib; and thus the meso-sternum has only two ribs. The præ-sternal rib belongs to the ninth vertebra; in front of it there are two equal in size to its *vertebral* part, but they have no sternal piece; in front of these we find the broad cervical ribs of the sixth and fifth, the latter half the size of the former; the first four vertebræ have no ribs. The "costal process" of the Bird's Sternum is not developed here; and the "ento-sternum" (e. st.) is not produced either fore or aft, as in the Bird, where we have usually a large "rostro-sternum" in front, and an immense development of the ento-sternum behind. This first appearance of that most important element—the "ento-sternum"—is as a narrow flat band (Plate XI, fig. 2, e. st.), small in size, undifferentiated at both ends, having neither rostral process in front nor meso-xiphoid plate behind; and without a trace of the "keel," so conspicuous in the Bird. It is cut off from the lateral parts of the Sternum by a long oval fenestra on each side (st. f.); these fenestræ are nearly half as long as the Sternum; their first appearance here is as instructive as their *last,* where they spring up again in the Cheiroptera, for instance, *Plecotus auritus* and *Vespertilio murinus.* The lateral "endosteal" plates have coalesced at the mid-line (see fig. 2), the ossific process being unusually active in this Lizard.

The "xiphisternal horns" (figs. 1 and 2, x. st.) are of extraordinary size, being more than twice the length of the unusually large Sternum; they are scythe-shaped, increase in breadth to the commencement of the last third, and then grow gradually to a rather sharp point; their direction is backwards, upwards, and a little outwards. These long "horns" have their own *internal* ossification, and there is a constricted isthmus of soft cartilage between these and the sternal angles; this constriction is an arrested transverse cleft. Such "horns" as these reappear in the Mammalian *Manis longicauda*, &c., and in the Bird-class their nearest counterparts are seen in the Tinamou.

The "costa intermedia" is well seen in *Stellio* (see Plate XI, fig. 8, where the first of these is shown as magnified eight diameters). The vertebral rib (v. r. 1) has an epiphysis, then the cartilage itself is constricted—*an arrested transverse cleft;* and at the eighth of an inch lower down another constriction appears; between these there is an "endosteal" mass of bone (i. r. 1), then below the lowest constriction we see the sternal rib (s. r. 1), which has its own internal ossification. Altogether, the *Stellio* Lizard has many most important morphological characters, the first outlines of things not clearly seen as yet, but which in due time manifest themselves in the Warm-blooded Classes.

Example 9.—*Polychrus marmoratus*, Linn., sp.

This Lizard is introduced here because of its correspondence in a very important character to the Chamæleons, which come next after the more typical Lizards. In a half-grown specimen of *Polychrus marmoratus* I find the main part of the Sternum lozenge-shaped, and having two pairs of ribs articulated to its postero-lateral edges. At a short distance behind the second pair of ribs the Sternum is constricted, it then becomes narrow, and has parallel edges, and this narrow part is composed of two halves not much coalesced together, indeed entirely distinct in their hinder half. The third pair of thoracic ribs are only partially segmented from the middle of this narrow piece, and the fourth pair are continuous with its halves behind, bending outwards from it at an obtuse angle; this is exactly intermediate, morphologically, between what has been described in the Iguana and the Cyclodonts (see Plates IX and X). The next nine costal arches meet and coalesce below, each arch forming a small, triangular plate at the junction of the right and left ribs; these plates are rudimentary "meta-sternals." In this specimen there is no separate ossification for this mesial part, but I shall presently show such a deposit in the "meta-sternal" of the Chamæleon. The tenth abdominal ribs are small, and do not even meet at the mid-line; they are a long distance from their own *vertebral* segment. The ninth "abdominal" ribs also are separated considerably from the vertebral parts of the arch.

We now come to the Chamæleons, in which there is an entire absence of the Shoulder-splints; but before giving the result of my own observations, I will insert those of Rathke. These are especially interesting, as in both *Chamæleo vulgaris* and *C. pumila* his descriptions indicate a much lower morphological stage than those dissected by me.

RATHKE, '*Brustbein der Saurier*,' pp. 17, 18.

§ XIII. The Sternum in the Chamæleonidæ appears to be of simpler structure than, so far as present observations show, in any of the remaining typical Scaly Reptiles. A portion of the skeleton which corresponds to the anterior portion of the Sternum [*inter-clavicle*] of other Scaly Reptiles wholly fails here. Their entire Sternum, indeed, consists only of one piece, which, to all appearance, never ossifies, but always remains cartilaginous [*in that case his specimens must have been very young*]. It is, moreover, in relation to the whole length of the body only of moderate length, and in relation to its own length only of moderate breadth, though this varies in different parts. On the whole, however, it has the form of a small table. Anteriorly, where it is broadest, there may be observed two borders of equal length, which become continuous with one another at a rounded, obtuse angle. These borders run outwards and backwards, and with these the hooked clavicle bones [*coracoids*] are connected, just as the same bones are connected to two similar borders of the posterior sternal piece of other Reptiles. From these borders, especially in *Chamæleo vulgaris* and *Cham. pumilus*, to as far as about its posterior fourth, it becomes gradually smaller; then again it is somewhat broader, and finally, near its extremity, it is bevelled off like a chisel. The nick formed by and at the extremity is sutured together by condensed connective tissue. A prolongation of this connective tissue, proceeding from the centre, fills a short longitudinal fissure, which divides the posterior part of the Sternum into two lateral halves, indicating a pair of horns.

After what has been said it is obvious that we may thus differentiate two sections in the Sternum of Chamæleons, an anterior and longer one, and a posterior and shorter one, the limits of each of which are indicated by the smallest part of this part of the body, and of which the former may be compared with the greater or anterior division [*præ-meso-sternum*] of the posterior Sternal piece; the latter, with the posterior division or to the asymmetrical appendage [*xiphoid process*] of the same piece of the skeleton of other Scaly Reptiles.

B. *Shoulder-girdle without "Splint-bones."*

Example 1.—*Chamæleo vulgaris*, Duméril.[1]

My dissections of the common species of Chamæleon are figured in Plate XI, figs. 4—6, showing the parts as magnified two and eight diameters. The Shoulder-girdle of the Chamæleon agrees with that of *Chirotes* (Plate VIII, figs. 8—10), and not with that of the more typical Lacertilia. Each moiety (Plate XI, fig. 4) is nearly vertical in position, and is one continuous osseo-cartilaginous piece. The supra-scapula (s. sc.) is of the usual form, but is relatively small; it is entirely unossified, even in an old individual. The scapula (sc.) is a very narrow rod, flattened, and curved backwards; it is broad above, where it defines the supra-scapular region, and below it is broader still; the præ-scapular region is entirely deficient, and the meso-scapular (m. sc.) is represented by the widened antero-inferior part; the scapula is a perfect shaft-bone, being entirely surrounded by the ectosteal sheath. The coracoid (cr.) is ossified in the same manner, but it is imperfect, just reaching the scapula above, and having a perfectly soft "præ-" and "epi-coracoid" continuous headland; the osseous laminæ commenced on the posterior selvedge

[1] For an invaluable monograph of these aberrant Lacertians, I refer the reader to Dr. Gray's paper ('Proc. Zool. Soc.,' 1864, part iii, pp. 465—479, pls. xxxi, xxxii).

running forwards on both faces of the cartilaginous plate. The whole of the coracoid mass is thrice the breadth and half the height of the scapula; it is of considerable thickness, and is pierced by the cutaneous nerve as usual (c. fo.), but there is no "fenestra." Thus we see that this Shoulder-girdle is less developed than that of *Chirotes*, which has the supra-scapula endosteally ossified, and the development of the scapular and coracoid shafts much more perfect. Altogether, this is scarcely in advance of what is seen in the Urodelous Amphibia.

In my specimen the ossification, as well as the morphological condition of the Sternum, is very much in advance of that (or those) dissected by Rathke; this may partly be accounted for by supposing a difference of age, but is, I have no doubt, mainly attributable to *individual* difference: moreover, the two halves of the body may vary very considerably. The Sternum (Plate XI, fig. 5) has quite a Mammalian character, like that of *Chirotes* (Plate VIII, fig. 8), but more advanced, and having proper costal hoops connected with it. The manubrium (præ-sternum, p. st.) is arrow-shaped; it becomes suddenly narrow in front of the first pair of thoracic ribs, and behind them is strongly notched on both sides: this constriction answers to the transverse cleft so constant in the Mammalian Sternum. There is behind this semi-cloven part an elegant, narrow continuation (m. st., x. st.), having three equidistant enlargements; with the first and second of these the second and third thoracic ribs articulate by synovial joints: the last enlargement is the bilobate extremity of the xiphisternum (x. st.). Contrary to what Rathke describes, we have here the usual right and left double endosteal plates; these are deficient along the mid-line and coracoid lips (p. st.): these plates are very thin, and have cartilage in considerable quantity, both between them as a *pith* and outside them as a *bark*. There is a sternal rib attached behind the left coracoid groove (figs. 4, 5); this is attached by fibrous tissue to the pointed, *soft* end of the long rib growing from the fourth cervical vertebra; the three before it have no free ribs: behind this comes the long rib of the fifth cervical; this has a rudimentary sternal piece continuous with it, which is free, and is hooked backwards (fig. 4). On the right side (fig. 5) no distal sternal piece occurs. Behind the xiphisternum there are seven pairs of *floating* ribs that become fixed by growing towards each other, and have united by suture at the mid-line,—all save the first pair (ar. 1), for these coalesce with each other, and grow forwards into a supplementary sternal plate ("metasternum"); this part (m. t. s.) is shown twice the natural size, and also magnified eight diameters in fig. 5. The little "metasternal" plate is wedge-like, emarginate in front, and concave behind: it has its own "endosteal" laminæ, and is therefore considerably differentiated as a separate morphological element. Behind these seven highly elastic costal hoops there are three pairs of ribs that do really *float;* but they have their "abdominal" counterparts, although at a considerable distance from the vertebral portion (see fig. 4, r. 13—15): the last of these are very small, but they meet at the mid-line (fig. 5, r. 15). The "costa intermedia" (i. r.) attains its highest development here (see fig. 6, which shows that of the second thoracic arch of the right side magnified eight diameters); it is a heart-shaped mass, very nearly severed from the vertebral rib above, and from the sternal rib below. The vertebral shaft-bone (v. r.) nearly reaches to the upper transverse cleft; the endosteal tube (filled and covered with soft cartilage) of the sternal rib (s. r.) nearly reaches the lower, narrow isthmus: as for the "intermediate rib," it has its own endosteal ring.

Rathke (p. 125) speaks of the common Chamæleon as having two pairs of ribs attached to the larger anterior part of the Sternum, and one pair to the smaller posterior part: in *C. pumila* he found two to the anterior and none on the posterior part. There must be great variability in these creatures as to their Sternum, as I find one and an odd one to the anterior piece, and two to the posterior in *C. vulgaris*, and in *C. pumilus* one and three. Moreover, morphologically, his specimen could not have been further advanced than the Cyclodonts (see Plate X), where the double sternal horns have partly united together at the mid-line; and by segmentation have nearly made, from those horns, two additional sternal regions.

Example 2.—*Chamæleo pumilus*, Gmelin.

My specimen of *Chamæleo pumilus* is further advanced than any described by Rathke, but it has enabled me to reconcile his descriptions with my observations. I find no connection of a cervical rib with the Sternum; and there is, therefore, only one pair united with the præ-sternum, which is shaped like that of *C. vulgaris*. The two halves of the meso-sternum are well united, and the whole Sternum is well ossified for a Lizard. The first and second thoracic sternal ribs are rather near each other; then there is a long "internode;" and then two pairs very near each other, as in *Cyclodus* (Plate X); between the last pair of sternal ribs the Sternum is emarginate, and these ribs are imperfectly segmented from it, exactly as in the Cyclodonts. Behind the fourth thoracic rib-girdle comes an arch with a small metasternal, and then the ribs merely meet, and unite by suture. Now, it appears to me that my specimen of *C. vulgaris*, when in an early stage, had its fourth pair of thoracic ribs entirely detached from the short xiphi-sternal horns; that these severed ribs, whilst the creature grew in length, became more and more removed from the third pair, and that they then met, coalesced, and, growing *pedate*, formed the "metasternal plate." Meanwhile, the short xiphisternal horns, being free, grew not only towards each other and coalesced, but also grew backwards, so as to form a free, single xiphisternum, exactly like that of an ordinary Mammal.

That there is no real difference between these two Classes in the formation of the xiphi-sternum I feel certain, for the condition of the Sternum here described in *Chamæleo pumilus*, and also in the Cyclodonts, is precisely what I must describe, in the sequel, in the Delphinoid Cetacea.

I will now give some very important remarks of Rathke upon the number of ribs connected with the Sternum, and then compare his observations with my own.

RATHKE, '*Brustbein der Saurier*,' pp. 18, 19.

§ XIV. In the typical Scaly Lizards several ribs are always in relation with the Sternum; still, in relation to their own number only one or two are in intimate connection with it. In these the Sternum usually consists of an anterior [*inter-clavicle*] and a posterior segment [*true Sternum*]; and then when this is the case it is always the latter which is connected to several of the ribs. But of this segment, again, it may be either only the anterior division, and thus the most extensive part of the whole Sternum, which is connected with the ribs, or it may be exclusively the posterior division, which usually forms a movable, and either simple or double appendage, or more rarely a pair of symmetrical prolongations. The latter, indeed, occurs in some Scaly Reptiles in which the appendage alluded to consists of two horns terminating in the muscles with free extremities, whilst a pair of ribs have united themselves with these horns at a distance from their extremities. But, generally speaking, the number of the ribs which are intimately connected with the Sternum, and to which the name of 'true ribs' can be applied, not only varies with the genus, but is also very various in different species, as may be seen from the following table, in which, moreover, those species possessing sternal horns with free ends are indicated by an asterisk.

Of the ribs there are connected in—	With the anterior division of the posterior sternal piece.	With the posterior division of ditto.
Chamæleo pumilus . .	2 pairs.	0 pairs.
„ *vulgaris* . .	2 „	1 „
Varanus niloticus . .	2 „	1 „
„ *ornatus* . .	2 „	1 „
„ *bivittatus* . .	2 „	1 „
**Agama mutabilis* . .	2 „	1 „
**Lyriocephalus margaritaceus* .	2 „	1 „
Seps Chalcidica . . .	2 „	1 „
Anolis Carolinensis . .	2 „	3 „
Polychrus marmoratus . .	2 „	3 „
**Draco viridis* . . .	3 „	0 „
**Phrynosoma Harlanii* . .	3 „	0 „
**Phrynocephalus caudivolvulus* .	3 „	0 „
**Agama colonorum* . .	3 „	1 „
**Lophyrus giganteus* . .	3 „	1 „
**Istiurus amboinensis* . .	3 „	1 „
**Basiliscus mitratus* . .	3 „	1 „
**Moloch horridus* . .	3 „	1 „
**Stellio vulgaris* . . .	3 „	1 „
**Zonurus cordylus* . .	3 „	1 „
Tejus Teguixin . . .	3 „	2 „
Ameiva vulgaris . . .	3 „	2 „
Lacerta agilis . . .	3 „	2 „
Lacerta ocellata . . .	3 „	2 „
Platydactylus guttatus . .	3 „	2 „
„ *ægyptiacus* .	3 „	2 „
Chamæsaura anguina . .	3 „	2 „
Euprepis Merremii . .	3 „	2 „
„ *bistriatus* . .	3 „	2 „
Cyclodus nigroluteus . .	3 „	2 „
Gongylus ocellatus . .	3 „	3 „
Calotes pictus . . .	3 „	3 „
**Uromastix spinipes* . .	4 „	0 „
**Grammatophora barbata* .	4 „	0 „
Iguana tuberculata . .	4 „	2 „
Agama umbra . . .	4 „	2 „
Oplurus torquatus . .	4 „	2 „

Tiedemann has stated ('Anatomy and Natural History of the Dragon,' Nürnburg, 1811, p. 14), that *Draco viridis* possesses six pairs of true ribs, which are connected with the lateral edges of the perfectly lozenge-shaped Sternum. Meckel has also stated ('Syst. of Comp. Anat.,' part ii, section i, p. 432) that in the *Draco* the six anterior pairs of ribs are attached to the Sternum. But in a skeleton, and in a specimen kept in spirits, I found, indeed, six pairs of ribs lying in the abdominal walls, that presented a strongly arched form, but only three pairs of these actually reached to the Sternum, and were attached to it, on which account I hold that these alone can be considered to be true ribs.

My own observations (recorded above) are as follows:

Ribs connected with—	Anterior part of sternum.	With posterior part.
Iguana tuberculata	4 pairs.	2 pairs.
Læmanctus longipes	4 „	2 „
Cyclodus nigroluteus	3 „	2 „
Trachydosaurus rugosus	3 „	2 „
Psammosaurus scincus	2 „	1 „
Monitor dracæna	2 „	1 „
Hemidactylus ——?	3 „	2 „
Stellio cordylinus	3 „	0 „
Polychrus marmoratus	2 „	2 „
Chamæleo vulgaris[1]	1 „	2 „
C. pumilus	1 „	3 „

Here it is seen that my observations agree with those of Rathke as to the *Iguana*, the Cyclodonts, the Varanians, and the Gecko; but not with regard to *Stellio*,[2] *Polychrus*, and the two Chamæleons examined by me.

Further observations are needed to show whether some types are really more variable than others, and what is the greatest variation in the adult condition of the most variable types.

Before describing my own dissection of the Crocodile, I shall give Rathke's important observations.

Rathke, '*Brustbein der Saurier*,' pp. 20—26.

§ XV. In the Crocodiles, or *Sauri loricati*, the Sternum is composed, as in the majority of the Scaly Reptiles, of two unsymmetrical pieces of unequal size [*Sternum proper and interclavicle*]. The chief segment that possesses considerable length in proportion to that of the body, partly resembles the Sternum of Chamæleonidæ in form, partly the chief segment of the Sternum of those Scaly Reptiles in

[1] In my specimen there was a feebly developed additional sternal rib on the left side (see Plate XI, figs. 4 and 5). W. K. P.

[2] The union of ribs with the "free sternal horns" which Rathke speaks of (p. 125) must merely be by connective tissue, the line of union being the enlarged longitudinal cleft which first separated the rib from the xiphisternum.

which this piece is prolonged into two horns, terminating in the muscles. For its body consists, as in Chamæleonidæ, of two differently shaped segments, passing one into another without interruption, and placed one before the other. The anterior has nearly the form of a lozenge, and is in connection, by its antero-lateral borders, with the hook-clavicles [*coracoids*], and is much broader but shorter than the posterior. It commences small, but gradually increases towards its extremity, until it is about three times the breadth that it was at first. In an example of *Crocodilus acutus*, four feet seven inches in length, the largest I have dissected, the length of the anterior segment [*præ-sternum*] of the greater piece of the Sternum amounted to two inches one line, the greatest breadth one inch eleven lines, whilst the length of the posterior segment of this piece of the Sternum was two inches eleven lines, and its greatest breadth ten lines. The horns of the Sternum [*xiphisternals*] appeared as prolongations of this piece, and thus are *not* movably connected with this by fibrous tissue. The horns spring from the Sternum, in close contiguity, but diverge widely, are of moderate length, but of small breadth, become attenuated at their extremities, are flattened from above downwards, and form a pair of moderately convex arches, whose concave edge is turned forward and outwards. Their relative length varies somewhat in different species. Thus, the proportion of their length to that of the greater segment of the Sternum is, in

	Feet.	Inches.	Lines.		
Crocodilus acutus . .	4	7	0	long	= 0·65 : 1
Alligator lucius . .	3	4	8	„	= 0·69 : 1
Alligator palpebrosus .	1	1	9	„	= 0·69 : 1
Crocodilus vulgaris .	2	9	6	„	= 0·78 : 1
Alligator punctulatus .	1	0	0	„	= 00·1 : 1

The other or smaller division of the Sternum [*inter-clavicle*] lies beneath the lozenge-shaped plate of the anterior, usually extends to the extremity of this plate, and always projects to a moderate extent beyond it. As in the Scaly Reptiles, it lies in a corresponding fissure or groove of the larger piece, and is connected to it in a similar fashion. As regards its form, it appears as a long, small, tabular plate, rounded at the extremities, but not possessing everywhere the same breadth and thickness. It is broadest under the most anterior part of the lozenge-formed plate of the Sternum, and from this point becomes smaller towards the extremities, especially towards the posterior extremity; on the other hand, it gains in this direction proportionately in thickness. There are no indications whatever of lateral prolongations. The larger piece of the Sternum [*true Sternum*] is cartilaginous, yet in spots in the interior of older specimens, differing considerably in different individuals, sometimes extensive and sometimes of only limited extent, we may occasionally find irregular deposition of calcareous salts, which, as in the larger sternal piece of Scaly Reptiles, appear to form heaps of small granules. The other or smaller piece of the Sternum [*inter-clavicle*] is always thoroughly ossified, and contains bone-corpuscles in tolerably close proximity to one another, having many canaliculi, and possessing a roundish or more or less elongated form. In very young Crocodiles, that have recently escaped from the egg, this piece is already quite compact. But as they grow, a certain number of medullary cavities of moderate size make their appearance.

In a specimen of *Crocodilis acutus* somewhat more than four and a half feet long it presented the appearance of a spongy mass surrounded or invested only by a few lamellæ of compact tissue.

With the major piece of the Sternum in the Loricata a larger number of ribs are connected than is the case in Scaly Reptiles. Thus, in the Alligators, in the *Crocodilus vulgaris* and in *Crocodilus acutus*, it is in relation with seven; in *Crocodilus biporcatus* with eight, and in *Gavialis Schlegelii* with nine pairs. The majority of these are attached to the body of this piece, but a few to the anterior part of its horns—to wit, one pair in *Crocodilus vulgaris*, two pairs in *Gavialis Schlegelii, C. acutus, C. biporcatus, Alligator lucius, A. sclerops, A. cynocephalus, A. punctulatus*, and *A. palpebrosus*.

§ 16. The result of researches which I have instituted in embryonic specimens of *Lacerta agilis* and Crocodiles of different ages[1] has shown that the Sternum in these Reptiles consists also, as follows from my former researches on Birds and Mammals,[2] in the first instance of two proportionately very small, band-like, straight bodies, alike in form and size, and composed of a firm cellular mass. These in the anterior half of the body diverge from one another, are split upon the two lateral halves of the body, uniting on each side with several consecutive ribs; on the whole they lie widely separated from one another, and are connected by a portion of the inferior uniting skin. Gradually they approximate, and after the lapse of some time come quite anteriorly, and subsequently also more posteriorly, into contact with one another. Their approximation depends upon the circumstance that the intervening portion of uniting membrane becomes constantly smaller by absorption. On the other hand, the peculiarly and primarily extremely small lateral walls of the trunk, the anterior halves of which likewise present a raphé beneath the band-like lateral halves of the Sternum, constantly become broader. From this circumstance, moreover, the two large pectoral muscles attached to them, which likewise primarily lie far removed from one another, increase in *breadth*, both absolutely and relatively; but the ribs, especially all the true ribs, increase in *length*, not absolutely alone, but also in proportion to the length of the body. As the lateral halves of the Sternum are first in contact anteriorly, so they coalesce gradually from before backwards. In reference to this process there is so far a remarkable difference between these Reptiles and the higher Vertebrata, that in the latter the lateral halves of the Sternum coalesce throughout their whole length, whilst in the former this only takes place to a partial extent. In these Reptiles they remain divided posteriorly to a moderate extent, and these separated lateral portions form in these posterior parts, in adult life, the two horns of the Sternum. Moreover, in Lizards, in the anterior part, though certainly only to a small extent, no coalescence occurs of the two lateral halves of the Sternum, and at a later period this spot appears, after a portion of the Sternum has attained a considerable breadth, as a space or fontanelle of considerable size filled up with fibrous tissue. Such a fontanelle was apparent already in nearly mature embryos of Lizards; but was in them of proportionately much smaller size than in adults.

The horns of the Sternum never project in Lizards over the last pair of (*i. e.* the last true) ribs attached to them; in Crocodiles, however, they reach beyond the ribs at first, though only to a slight extent, increase in the extent to which they project over them, constantly further and further, and at the same time curve outwards. The lateral halves of the Sternum have already at the time when they have coalesced by their anterior extremities a somewhat greater breadth anteriorly than elsewhere. In the Lizards the wider portion is of greater extent than in the Crocodiles. In the further progress of embryonic development these anterior broader parts of the Sternum increase in breadth, not only absolutely, but also in proportion to the extent of the posterior narrower portion, and form the lozenged-shaped plate of the Sternum. When the embryo leaves the egg the general form of this piece of the skeleton composed of the above-mentioned two pieces are already the same as in adults of this species.

The moderately dense mass, composed of closely compressed cells, of which the two lateral halves of the Sternum originally consist, soon become converted after these two parts have united anteriorly into true cartilage. In the Crocodiles this change takes place without interruption through

[1] I have dissected nine embryos and several young ones amongst the Crocodiles, of which the smallest embryo was two inches two lines long.

[2] 'Archiv. f. Anat. u. Phys. v. Joh. Müller,' 1838, pp. 363—366.

the whole length of the two lateral halves of the Sternum; but in the Lizards a fibrous tissue is formed out of these cellular masses at those points of the Sternum to which the horns and the shield-shaped plate subsequently become movably united. An articulation of this kind I could already discover in embryos whose cutaneous investment could have only just begun to be coloured. Calcareous deposit takes place in Lizards, as well as in other Scaly Reptiles, both in the shield-formed plate and also in the horns of the Sternum, at a later period, subsequent, indeed, to the time at which the animal has left the shell, for in all young specimens of *Lacerta agilis* and of *Tejus Teguixin* I found the parts in question in a completely cartilaginous condition.[1]

In Lizards and Crocodiles the smaller or so-called anterior sternal bone [*inter-clavicle*] first makes its appearance after the two lateral halves of the Sternum have united to a considerable extent, and have obtained a moderately thick fibrous investment as perichondrium. It originates on the under surface of the Sternum in the substance of the above-mentioned fibrous tissue without any primary formation of cartilage. Immediately after its first appearance, whilst yet forming an extremely delicate pencil, pointed at both ends, it is composed of true bone, in which bone-corpuscles, with a few canaliculi, may be clearly recognised. Nevertheless, this mass I have particularly noticed in young embryos of Lizards is for some time so soft that it is easily broken down by slight pressure. At a later period, when it has become more firm and hard, there may always be found, as I have seen in young examples and in embryos of Crocodiles, and also in young specimens of Tejus Teguixin, a thin investing layer of a soft blastema, essentially composed of elementary cells, which likewise, without previous conversion into cartilage, ossifies, and serves to add to the dimensions of the anterior sternal piece. Consequently this piece of the Sternum is to be enumerated amongst the so-called secondary bones, or is to be considered as an investing (opercular) bone for the other piece of the Sternum, from which it constantly and remarkably differs in its structure. The anterior piece of the Sternum, soon after its formation, develops so as to cover the anterior part of the posterior segment [*manubrium*], in consequence of which the projecting part becomes surrounded and invested by a portion of the perichondrium of the other piece. Moreover in Lizards the projecting portion throws out at an early period a pair of lateral prolongations, which quickly increase in length. In older and nearly mature embryos of Lizards it has the same form of a cross as it has in adults, and is also similar, in the proportion of its size, to that of the posterior piece, as in adults.

§ XVII. In two embryos of *Anguis fragilis*, which were two inches three or four lines long, the Sternum appeared to be much smaller, in proportion to its length, than in adult specimens of this species, and had nearly the form of a square with rounded angles; it differed, however, from a perfect square in that it was a little narrower posteriorly than in front, and that the posterior border had a shallow indentation in the middle. It was composed of a thin cartilaginous plate and a still thinner and much smaller plate of bone [*inter-clavicle*]. The latter lay under the anterior half of the former, was united with it by fibrous tissue, and approximated to a triangle in form. The three edges were slightly concave, two of the angles were rounded, and the remaining posterior angle was directed backwards, and prolonged into a moderately long point. Bone corpuscles with caniculi could be clearly distinguished in it. With the hook clavicles [*coracoids*] the Sternum was intimately united, but it was not very closely connected with the neighbouring ribs, lying at a much greater distance from them than in adult Blindworms. There cannot, consequently, be any doubt that in the Blindworms the two lateral halves of the Sternum do *not*, as in Lizards, Crocodiles, Birds, and Mammals, originate immediately under the ribs, and unite with them, but develop at a distance from the ribs.

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[1] These young specimens of *Tejus Teguixin* were three in number. A cicatrix at the umbilicus was still perceptible, although they had already attained a length of nine inches four to seven lines.

§ XVIII. If we now review what has been advanced concerning the structure and development of the Sternum in various Saurians, we may conclude from the results of direct observation that in their position, composition, and form they bear a close resemblance to the similar structures in allied Vertebrate animals, and that they also originate and develop in a similar manner. In regard to the development of the Sternum in the Saurians the following general facts may be admitted:

1. In a few of these animals, especially in those of the Genera *Acontias, Chirotes,* and *Chamæleo,* the Sternum is developed from two morphological elements corresponding in form and size, commencing at a distance from one another in the lateral halves of the body, and subsequently coalescing. A short time after their appearance they form well-marked cartilage. In the majority of Saurians, however, a third piece joins itself to the two similar symmetrical lateral pieces which are here also formed. This third piece [*inter-clavicle*] takes origin in the middle line of the body, beneath the symmetrical pieces, and subsequent to their union. It never presents the character of cartilage at any period, but undergoes ossification.

2. The two symmetrical morphological elements of the Sternum originate for the most part close under the several ribs, unite these together at their lower ends, and continue persistently in intimate connection with them. In the Atypic Scaly Reptiles, however, they originate at a distance from the ribs, and never enter into intimate connection with them.

3. As a rule these two elements coalesce with one another after they have come into lateral opposition. But in *Acontias meleagris,* in which, speaking generally, the Sternum remains in the lowest grade of development, they indeed approximate closely, but never actually coalesce.

4. When these parts are only of small extent, proportionately to the whole body in the first instance, on subsequently coming into contact with one another, they completely coalesce and form, after undergoing considerable increase in accordance with the general growth of the body, a simple and continuous plate, as occurs in the general *Ophisaurus, Anguis,* and *Pseudopus;* but if they are of proportionately moderate length they rarely unite with one another throughout their whole length, as for example in *Gongylus ocellatus*, but usually remain divided to a greater or less extent, either posteriorly where they are narrow, or also frequently further forwards, where they increase in breadth; in consequence of which, in a state of complete development, there may be remarked in the Sternum a pair of horns posteriorily, and more anteriorly a fontanelle.

§ XIX. The posterior half of the anterior segment of the Sternum [*inter-clavicle*] projects in many Saurians in which it has attained only a small breadth in proportion to its length, as, for example, in the Varanidæ, beneath the other or larger piece of the Sternum, and thus forms an inferior keel beneath the other. It appeared desirable, therefore, to me to determine whether, in Birds and in those Saurians which possess a keel to their Sternum, this arises in a similar manner to the anterior Sternal piece of Saurians, in the perichondrium of the sternal plate, and subsequently, as in a few Saurians, coalesces with this plate.

But both in the embryos of Fowls, and in young Sparrows, I found that the keel of their Sternum was formed of true cartilage, and that this was continuous without interruption with the still cartilaginous plate of the Sternum, of which it appeared to be an outgrowth. The same was the case in older embryos of Bats, and in newly born Moles, whose Sternum already possessed a small keel.

§ XX. A few anatomists have regarded the anterior or accessory of the two pieces out of which, in the majority of Saurians, the Sternum is composed, as equivalent to the 'manubrium sterni' of Mammals. But the 'manubrium sterni' in Mammals is developed (if the two originally divided lateral halves of their Sternum—which correspond to the symmetrical morphological elements of the Sternum of Saurians—have united) out of the most anterior parts of the same, whilst these parts increase in breadth to a greater degree than the longer portions of the already mentioned lateral halves of the Sternum lying behind them. It is therefore not indeed the accessory piece of the Sternum of Saurians, but rather the shield-formed plate, which is to be regarded as equivalent to the manubrium sterni of Mammals. It still might be considered a question whether the so-called episternal bone [*inter-clavicle*] of the *Ornithorhyncus* and *Echidna*, which, like the accessory sternal piece of many Scaly Reptiles, possesses anteriorly two lateral, transversely directed processes connected with the clavicle is not developed in the same way as this bony piece of the Saurians, and has a like morphological significance. We may admit, with some probability, that the same is no accessory element of the sternum, but a long piece corresponding to the 'manubrium sterni' of other Mammals, since its position is not partially under the remaining portion of the Sternum, but completely anterior to it.[1]

"Sauria loricata" (*Crocodiles*).

The clavicles absent, but the interclavicle developed.

Example.—Crocodilus acutus, Cuv.

The figures given (Plate XI, figs. 7—9) of the Sternum of this species are from dissections of a ripe embryo, which had still a large mass of yolk in its abdomen; they are magnified two and one third diameters.

The Shoulder-girdle moiety of the Crocodile (fig. 7) approaches very near to that of the typical Struthious Birds,—with the exception of the true *Struthio:* it has no transverse cleft across the glenoid cavity, and there are no "fenestræ." The supra-scapula (s. sc.), at present quite soft, is shaped like the blade of a hatchet; and, like that of the Chamæleon, is less, relatively, than that of a Lacertian. The scapula (sc.) is a flattened but thick bar, ossified all round, and somewhat expanded above and below: at present, a large tract of cartilage intervenes between this "shaft" and the coracoid. Behind, this mass of hyaline cartilage is scooped to form the glenoid cavity; in front it expands and forms a short hook, the rudiment of the præ-coracoid (p. cr.); a very small rudiment it is, not equal to that of the Rhea and Emeu (see Plate XVII, figs. 4 and 7, p. cr.). Properly speaking, the concave open space forming the front margin of the coracoid, is the coraco-præ-coracoid notch. The coracoid shaft-bone (cr.) is equal to the scapula in strength, but it is one-fifth shorter: its epicoracoid region (e. cr.) is quite soft in the ripe embryo; the two main bars meet at a very obtuse angle. There is one splint to this Shoulder-arch,—the interclavicle (i. cl.); it is long-lanceolate, moderately thick at its narrowest part, which is nearly two-fifths of the entire length of the whole bone. As Rathke truly says, this piece is formed entirely in fibrous tissue; that it is moderately hard when first perceptible, and that it soon becomes dense by fresh development of bone-cells in the surrounding blastema: it is totally unlike the true Sternum, being merely a *subcutaneous* derm-bone. At first sight this bone looks so like the præ-sternal "rostrum" of the Heron (*Ardea*), that it might easily be mistaken for it: fig. 9 shows it from above, and how that it fills the groove below, and emerges from the notch in front of the

[1] This last remark of Rathke is the only one from which I must differ, for the three clavicular bones of the Monotremes agree in all respects with those of the Saurians, and my figures (Plate XVIII) show that the anterior part of the manubrium *does lie inside* the straight bar of the T-shaped piece; of which more hereafter.

præ-sternum (p. st.); and fig. 7 shows that, like the "rostrum" of the Heron's Sternum, it is laterally compressed.

The three divisions of the Sternum are very distinct (fig. 8); the first of these is the præ-sternum (p. st.); it is a many-sided plate, and the margins are not very straight. The anterior margin (see fig. 9) is concave on both sides, and notched in the middle: this notch is the anterior remnant of the original fissure between the sternal moieties. Antero-laterally the margins are gently concave and deeply scooped (see fig. 7, p. st.), to receive the epicoracoids; but the postero-lateral margins are bowed out, and protrude in two places to receive the first two pairs of ribs: the synovial surfaces for these are, as usual, cupped. There is a deep rounded notch on each side, partly severing the "præ-" from the "meso- sternum" (m. st.); this latter part, at first very narrow, widens gently, until it ends in the xiphisternal horns (x. st.); a conspicuous groove indicates the original division of the meso-sternum into two halves. Four pairs of sternal ribs articulate with the meso-sternum by their rounded ends; whilst a fifth pair, with pointed ends, come nearly into contact with it. The meso-sternum is one-third longer than the præ-sternum; and it is exactly intermediate in length between the right and left xiphisternal horns; the left of these arcuate, pointed rods being one-fourth longer than the right (see fig. 8). These terminal horns keep close behind the pointed *semi-floating* ribs, from which they have evidently been segmented by a longitudinal cleft: if this cleft had not appeared the sternal horns would have been one with the seventh thoracic ribs, just as the third thoracic ribs and the sternal horns form one continuous bar in the Monitors (see Plate X).

The sternal ribs are very thick at their upper third; they then attenuate where they join the "intermediate" part of the vertebral rib: this part, still wholly cartilaginous, like the sternal ribs, is narrow below and then expands (fig. 7). The junction is here by a "synovial" joint, as in the Cyclodonts, an ornithic character, and which also reappears in certain Mammalia: the seventh joint is seen to be unfinished in front. There are two pairs of ribs joined to the manubrium (præ-sternum); these agree to the last cervical and first dorsal of the Tamandua; it is only by *specialization* that the proper typical number of manubrial ribs is attained; these should be only one pair, as we see constantly in the Mammalia.

Behind the Sternum there are delicate bones looking like the abdominal ribs of *Chamæleo* and *Polychrus;* they are very slender, and wholly ossified (see Plate XI, figs. 7 and 8, a. sp.); they are only separated from the *cutis vera* by a little fibrous stroma, and are indeed intermuscular septa ossified in their *outer part;* these septa are the "inscriptiones tendineæ musculi recti."

Cuvier ('Règne Animal') took this view of them; but Professor Owen ('Catal. Hunt. Mus.,' vol. i, p. 158) speaks of them as "long and slender cartilages," and considers them to be part and parcel of the costal girdles; their real nature is that of subcutaneous splints; they are, as it were, the abdominal plates of the Chelonians *broken up* (see the various figures in Plate XII.)

"CHELONIA" (*Tortoises and Turtles*).

Each moiety of the Shoulder-girdle a bifurcated rod, the hinder fork only having a separate ossification from the main bone; endoskeletal part of the thorax open below; clavicles and interclavicle forming the three anterior plates of a thoracic-abdominal (dermal) shield, which is composed altogether of nine bones.

Example.—Chelone mydas, Linn.

In the abstract of the present Memoir, 'Proc. Zool. Soc., 1864,' part 3, p. 339, I controverted Professor Owen's view of the *morphologically compound* nature of the Plastron of the Chelonia.[1] Professor Owen expressly says ('Ost. Catal. Hunt. Mus.,' vol. i, p. 169), that "The parial pieces of the Plastron are the 'hæmapophyses' connate with expanded dermal ossifications." In my paper (p. 340) I said, "There is no *connation* whatever; there is no Sternum at any time, and no hæmapophyses; nothing, indeed, but *membrane-bones* formed between the corium and the membrane lining the abdominal cavity. One bone, the azygous piece, answers to a similarly unsymmetrical piece in the thoracic apparatus of the Aves and of the Lacertilia, and had its counterpart also in the extinct Plesiosaurs and Ichthyosaurs, and also exists in the Monotremes." So far true: then I went on to mistake the furcula of the Bird—the fibrous part of it—for a single piece, and to confound the clavicles of the Lizard with the præ-coracoids of the Frog. Nor was I then aware that the so-called "episternals" of the Chelonian are really the "clavicles."

But the reduction of the Plastron to its true *dermal* simplicity was a right step; it was generously appreciated by Professor Huxley at the time, who at once put Rathke's splendid work on the Anatomy of the Tortoises into my hand. This work ('Ueber die Entwickelung der Schildkröten,' 1848) appeared one year before Professor Owen's paper was published in the 'Philosophical Transactions.' I now was made aware[2] that my observations had been forestalled some sixteen years, through a much more extended study of these creatures by the great German embryologist. If, however, Professor Owen had not *supposed* a "connation" of endo- and exo-skeletal parts in the Plastron his paper would have been almost faultless; and, in spite of this hypothetical deduction, it is of very great value. With regard to the connation of a large number of the ribs and neural spines with the supero-lateral and upper plates, of that there can be no doubt. In plates iii, v, and vi of Rathke's work, the continuity of the rib and the great dermal plate overlying it is shown again and again. My own observations agree with those of both authors (see Plate XII, fig. 6), which shows a transverse section of a rib of the eleventh vertebra of the ripe embryo of a Green Turtle (*Chelone mydas*) magnified ten diameters. A large cartilaginous core is seen within the "ectosteal" sheath; this sheath has grown more outwards than inwards, and shows a perfect circle of large diplöe cavities, and then it is seen to spread both fore and aft into the looser inner part of the thick corium. In the same Plate (fig. 5), the terminal free part of the

[1] See Owen "On the Development and Homologies of the Carapace and Plastron of the Chelonian Reptiles," 'Phil. Trans.,' part i, 1849; and 'Ost. Catal. Hunt. Mus.,' vol. i, pp. 168—170, No. 769.

[2] The part relating to the structure and development of the Plastron was kindly translated for me by Mr. Power.

second rib of the same young Turtle is shown, magnified six diameters; here it is seen that towards the lower part of the rib, the ectosteal sheath, at this stage, has not spread into the surrounding connective tissue, and that the rounded and flattened end is still unossified.

Rathke's description of the Plastron extends from p. 122 to 131: he commences with *Sphargis coriacea.*

RATHKE '*Ueber die Entwickelung der Schildkröten,' pp.* 122—131: 4*to, Brunswick,* 1848.

I found the Plastron most feebly developed in the young of *Sphargis.* It here consisted of four symmetrical arched and both relatively and absolutely extremely diminutive linear structures, everywhere of nearly equal breadth, and so arranged that the anterior pair were at a considerable distance from the posterior, and came into actual contact in the middle line, while the inner ends of the posterior pair only came into close proximity with one another at that point (plate iv, fig. 5, *a* and *b*).[1] Each strip[2] presented an osseous structure at its two extremities, whilst the middle part, for a considerable extent, was cartilaginous [gristly,—not composed of hyaline cartilage]. There were thus eight bony centres for the four processes. From near the posterior extremity of each anterior strip there proceeded a short, simple, pointed, horizontal process, running outwards, and representing the so-called ala of the Plastron. I was unable to discover any trace of an azygous piece. In a somewhat older specimen of *Sphargis* the Plastron was almost wholly ossified; but even here I was unable to discover any indication of a median piece. The eight osseous pieces of which it consisted were, even collectively, but small and thin. Those belonging to the anterior pair were the broadest, and presented at their posterior border a longitudinal fissure, which became deeper towards the inner extremity of the plate, making it appear at this part as if there were two bony laminæ, one superimposed upon the other. The osseous pieces of the anterior pair, moreover, sent forwards from their point of contact two diverging processes (plate ix, fig. 2[3]) of moderate length, very thin, but of considerable breadth, and of much greater size than in the younger specimens, where, however, they could also be perceived. The bony pieces constituting the second pair still lay at a considerable distance from those of the third; but whether or no [he adds in a note] in adults of the species *Sphargis,* the several bony pieces of the Plastron have only a small breadth, and if the azygous piece is absent, [he does not know].

In regard to the grade of development, the next to follow are the young of *Chelonia virgata* (plate vi, fig. 22). In these the Plastron[4] consists of nine bony plates, which are not connected with one another by cartilage, and of which the first pair are in close apposition to the second, and those of the third with the fourth. On the other hand, the second pair are farther distant from one another than is the case in the *Sphargis.* Moreover, the two anterior and the two posterior symmetrical pieces were on the whole small, whilst each of the four middle pieces had sent out, at nearly a right angle, and laterally, a moderately broad and long ala, which divided at its outer extremity into two horizontally disposed crura. The azygous piece was very diminutive, and was placed immediately behind the first pair, where these came into contact by their inner or anterior extremities. The Plastron of a young *Chelonia imbricata* presented a very similar conformation, except that its constituent pieces were all somewhat broader.

The Plastron of an embryo *Chelonia midas*[5] again was proportionately larger, plate iv, fig. 2. Its

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[1] The references here are to Rathke's own plates; in my 12th Plate figs. 10—17 are copied from those given by Rathke, and to these references are given in foot-notes.—W. K. P.

[2] See Plate XII, fig. 11, th. a.

[3] See Plate XII, fig. 12, cl., p. t. t.

[4] See Plate XII, fig. 14.

[5] See Plate XII, fig. 10.

azygous piece was relatively much longer and broader, and presented the form of an elongated and not perfectly isosceles triangle, with its point directed backwards. The symmetrical pieces were somewhat broader and thicker than in the young *Chelonia virgata.* In these embryos, also, the pieces forming the second and third pieces still lay far asunder. The future alæ of the Plastron appeared in the form of three or four dentations or striæ running outwards. Similar in their form and position were the several bony pieces constituting the Plastron in young embryos of Chelonians that appeared to me to belong to the species *Chelonia midas,* only that they were somewhat more slender than in that embryo. As appears from a comparison of the Plastron of these various specimens of Chelonians, the further stages of development must have consisted in the opposite pieces of the second and third pairs sending each a broad process inwards, by the union of which with each other, and with the remaining symmetrical pieces, a complete ring is constructed. Such a process appeared to me to be feebly developed in the second pair of pieces in the young of *Chelonia virgata.* The development of the Plastron of the embryo *Testudo*[1] had taken place to about the same extent as in the embryo *Chelonia* (plate iii, fig. 14). The asymmetrical piece in the former was of similar form, and of about equal size to that of the latter. The symmetrical pieces were likewise upon the whole only moderately broad ; those of the first and fourth pairs were somewhat narrower and altogether smaller than the remainder. From the bony pieces of the second and third pairs a wing extended outwards, of moderate length, perfectly simple, and tapering to a blunt point; not, however, as in the marine Tortoises, horizontally placed, but already, as in adult specimens, turning upwards with a moderately strong arch, and with its extremity directed inwards (from the annular fold of the cutaneous investment separating the belly from the back) until it reached the dorsal wall. Moreover, the bony pieces of the second pair were considerably more distant from those of the third than in the embryo or the young of *Chelonia.* Moreover the space around the nine bony plates of the Plastron was filled up with connective tissue, and in the centre was the umbilical opening, which was proportionately much larger than in the young of *Chelonia.* The Plastron in the remaining Tortoises examined was still further developed. Its symmetrical pieces were in contact as they followed one another from before backwards. Nevertheless, in *Trionyx ocellatus,* but especially in *T. gangeticus* (pl. vi, fig. 13),[2] and *T. ægyptiacus,* the pieces constituting the second, third, and fourth pairs were much narrower than in adult specimens of this genus, so that here the whole Plastron only presented a narrow ring, which sent out four horizontally running and only very narrow, but apparently long alæ. In *Emys europæa* (plate vi, fig. 15),[3] in *Emys lutaria,* in *Terrapene tricarinata,* and probably also in *Platemys* (plate vi, fig. 23),[4] the symmetrical pieces were proportionally smaller than in adult specimens; so that the Plastron composed of these pieces is only represented in *Platemys* by a broad ring, and in *Emys* and *Terrapene* it allows a series of well-marked spaces, which are connected with one another near the middle line, to be seen. Moreover, in *Pentonyx capensis* there are present in the Plastron three consecutive spaces of considerable magnitude and of various size, but they are no longer continuous with one another (plate vii, fig. 2).

From the preceding observations on the development of the Plastron in the Chelonians, the following conclusions may be drawn :

1. That in all probability the basis of the symmetrical pieces is laid down at an earlier period than that of the azygous pieces.

2. That the basis (mother-substance) of the symmetrical pieces consists of four cartilaginous [*gristly*] segments on the two sides of the body, in each of which, at a later period, *one bony point is developed.*

3. That the bony pieces of the second and third pairs, like the cartilaginous segments, from which they take their origin at first, lie at a considerable distance from one another ; and

[1] See Plate XII, fig. 16.
[2] See Plate XII, fig. 13.
[3] See Plate XII, fig. 15.
[4] See Plate XII, fig. 17

4. That in these latter portions the alæ originate at an earlier period than the prolongations which run parallel to the long axis of the body, by means of which they subsequently coalesce, and by uniting with the remaining symmetrical pieces, compose a ring.

In order to fill up with bone, to a greater or less extent, the remarkably extensive spaces only occupied by connective tissue, which in all Chelonians originally intervene in the middle line between the bony pieces of the Plastron, in many species some of these bones increase in breadth in this direction, sending in rays or outrunners, as Cuvier has already remarked in his 'Recherches' (vol. ix, p. 403), which either remain in this condition, as occurs in the marine Chelonians; or, increasing continually in size, coalesce in their entire length, until at length a solid flat table is produced. I remarked several of these rays in the young of *Chelonia* proceeding from the bones of the third pair, in the young *Platemys,* from the second pair, in the young *Trionyx ocellatus* from those of the second and third pair, in the embryo of *Testudo,* and in the young of *Emys europæa, E. lutaria,* and *Terrapene tricarinata,* from those of the second, third, and fourth pairs; in the last-named species they were the most numerous from each pair of bones. On the other hand, I have never observed them to proceed from the first pair of bones, nor from the asymmetrical pieces.

§ XXIX. As regards the process of ossification the several constituent pieces of the Plastron comport themselves similarly, though not quite identically with the plates of the Carapace. Ossification begins, as I have observed in the embryo of *Chelonia,* at about the centre of each piece, and indeed in their interior, like the supplementary plates of the carapace, and not on the *surface* of the cartilage[1] [*gristle*] of which they are primarily composed. When it is quite impregnated with calcareous material medullary canals are conspicuous, running or radiating outwards from the centre, sometimes branching at acute angles, containing medullary substance, lying in layers two to five deep, and, according to their position and length, either running to the margin of the pieces or opening upon the inferior surface. The canals of the lowest (nearest the cutaneous covering) layers are the shortest, those of the uppermost the longest. Still later, as in the back plates and ribs on that surface which is turned towards the skin there appear in these Plastron-plates medullary cells, seated apparently perpendicularly upon the canals, and in the first instance wide open externally. These medullary cells are filled, not with medulla, but with a loose connective tissue, and in their further development and multiplication (increase) behave themselves like other parts of the skeleton. A quite peculiar process is, however, found to take place in those cases where the several pieces of the Plastron have sent out several rays, especially in *Emys* and *Terrapene.* In the angle between each two rays a plate is formed consisting of osseous substance, which is in the first instance delicate, and often cribriform, apparently proceeding from the rays themselves, but by no means presenting the appearance of a superimposed mass lying on them. These plates gradually become thicker, become wider also as they approximate the tapering extremities of the rays, and come more and more to fill up the spaces intervening between them. As they increase in breadth there appear upon them, and on the rays connected by them, medullary cells of the same kind, and in the same method as has been already described in the remaining part of the Plastron. These cells are seen on that surface of the plates and rays which is turned towards the skin. I found scarcely any medullary cells, but only horizontally running medullary canals in the Plastron of the young of *Chelonia* and *Trionyx,* although in the latter species similar bony cells had already formed in abundance in the ribs and spinous processes.

§ XXX. I found the pieces of the Plastron just described (in all the Tortoises examined in a state

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[1] Rathke does not here speak of *hyaline cartilage,* but of a dense mat or web of nascent connective tissue, such as that composing the *cutis vera.* All splint-bones are formed in a "stroma" of this kind, and in studying Rathke's writings it is very necessary to ascertain whether he is speaking of this latter tissue or of true hyaline cartilage.

of development) situated *immediately* beneath the integuments, and most intimately connected with it by one or more layers of a very close connective tissue free from fat, which may be considered as a portion of the subcutaneous connective tissue very different, by reason of its closeness and firmness, from the interstitial cellular tissue, and sharply differentiated from it. On closer investigation it appeared that all the pieces of the Plastron originated in the layer just mentioned, so that these represented their matrix. For, in the embryos of *Testudo* and *Chelonia*, and also in the young of *Sphargis* and *Chelonia*, they appeared so sunken and enclosed in the layers of the subcutaneous connective tissue, that they appeared to be covered even on the superficial surface by a moderately thick plate or layer of this tissue, whilst the clavicles [*præ-coracoids*] and the muscles which are attached to the bones of the Plastron were only united by means of this strong connective tissue, and were completely separated from the Plastron by it. But the more advanced the stage of development of the young Chelonian, and the greater the thickness of the plates constituting the Plastron, by so much had the superficial or investing layer of connective tissue diminished in thickness, until, at length, it had become quite compressed, and ultimately vanished; so that at this period each bony plate was ultimately covered on its upper or deep surface by the periosteum, which was again followed by the looser interstitial connective tissue and muscular substance. Moreover, however little developed the Plastron might be, it possessed, in relation to the length of the body, a similar layer, as in the condition of its complete formation, of which the anterior part extended beneath the scaffolding of the Shoulder and its posterior part beneath the Pelvis. But, on the other hand, regarded in relation to the breadth of the body, the ends of its wings stood in the embryo of *Chelonia midas* (the back of which was far more convex than in the adult) not far from the border of the Carapace, even if it did not absolutely reach it, as in the young and in adult specimens of this species. Hence it may be concluded, that in *Chelonia midas* the subsequent flattening of the back is essentially occasioned by the circumstance that after the investment of the embryo the ribs gradually extend themselves, and consequently push the margins of the Carapace farther from one another. In three examples of *Trionyx* the perfectly horizontal alæ of the Plastron reached nearly, but not quite, as far outwards as the ribs; but in the other young Fresh-water Chelonians, in all of which the alæ stand more or less perpendicularly, they reached—in *Emys lutaria, E. europæa, Terrapene tricarinata,* and *Pentonyx capensis*—and also in the embryo of *Testudo*—as far as the annular border of the dorsal membrane and the extreme ends of a few ribs, whilst in *Platemys* the extremities of the anterior alæ lay close in front of the thinner halves of the second pair of ribs, and the extremities of the posterior alæ close behind the thinner halves of the sixth pair of ribs, and thus on the whole the ends of the alæ lay unusually close to the inner part.

§ 31. As to the significance of the Plastron, and of its several constituent pieces, the majority of anatomists opine that it precisely represents the Sternum of higher animals. Yet Carus and Peters have suggested that it is only equivalent to a portion of the Sternum of higher animals, part of it belonging to the dermal skeleton, and consisting of osseous plates which coalesce with the former. Neither of these views is, however, in my opinion tenable. As regards the latter I have not been able to discover in embryonic or young Chelonians, either here or in the ribs, any special bony plates beneath a somewhat earlier originating part of the Plastron which covered, and had then gradually coalesced with them. The Plastron of Chelonians, the several pieces of which originate near one another upon the same level, would thus, consequently, be admitted to represent, either on one hand the Sternum of other animals,—a mere portion of the animal skeleton [*endo-skeleton*], or, on the other hand, as only a part of the dermal skeleton. My opinion is, for various reasons, upon the whole not favorable to the whole Plastron being equivalent to the Sternum of other Vertebrata; nor, indeed, to its being a portion of the animal skeleton, but rather that it is a part of the dermal skeleton, upon the following grounds.

1. According to the researches I have made on the development of the Sternum in Mammals,

Birds, and Batrachia, this bone may be formed in a twofold fashion. In Mammals and Birds it occurs under the form of two very slender longitudinal rods, divided into two lateral halves, and already at an early period consisting of cartilaginous tissue, each of which rods unites itself with the extremities of several ribs of its own side when these project through a small part of the lateral wall of the body. The two halves, therefore, at first, lie at a considerable distance from one another. Gradually, however, these two rods are approximated to one another by the extension and development of the ribs, until, at length, they come into contact throughout their whole length and ultimately coalesce, forming the Sternum.

As regards the Batrachia, even in those which possess ribs, there are never at any time two rods which unite the ribs and coalesce with one another to form a Sternum, but in some of these Amphibia there originates, in order to supply the place of the Sternum of the higher Vertebrata, a single cartilaginous lamina; in others, a row of two or three such laminæ quite independently of the lateral rays of the vertebral column between the muscles which aid in forming the abdominal walls, and, indeed, close to the middle line of these walls. Now, at first sight, the plastron of the Chelonians appears to be related in its mode of development, on the one hand, in part with the Sternum of the higher Vertebrata, and on the other in part with that of the Batrachia. For, considering it according to the relations which I have observed in various young Tortoises, it originally consists in greatest part, like the Sternum of the higher Vertebrata, of a few cartilaginous rods, divided into lateral halves; and in a smaller part, as in the case of the Sternum of Toads, of a simple single plate lying in the centre (middle line) of the abdominal wall. These various parts, however, become in time connected with one another, and in many Tortoises, after the bony plates originating in them have much enlarged, they form only a single plate.

But on closer inspection it appears that the various pieces constituting the Plastron of the Chelonians can neither be regarded as equivalent to the Sternum of the higher Vertebrata, nor to that of the Batrachia. The lateral pieces, or the longitudinal rods, are connected with the ribs immediately, neither in the embryos, nor in the young, nor in the adult; but in many, especially in the young of *Sphargis,* they are situated at a considerable distance from the ribs, whilst in others the so-called alæ with which the pieces most nearly approximate the ribs, are obviously only prolongations sent out towards them. There can be little doubt, therefore, that these parts take their origin independently of and at a distance from the ribs, and thus, in regard to their mode of development, are very different from the Sternum of the higher Vertebrata. Further, according to the observations I have made in *Sphargis* and *Chelonia,* two pairs of such longitudinal rods are formed, which for a considerable period (perhaps always in *Sphargis*) remain far separated from one another; of these, one is situated in front, the other behind the umbilicus, so that the Plastron of these animals do not develop from before backwards, but from the growing together of parts of which some originally belong to the posterior half of the body. On the other hand, the basis of the Sternum of the higher Vertebrata, especially of Mammals and Birds, consists of only a single pair of longitudinal rods, occupying a position completely in front of the umbilicus, and there is this additional circumstance which constitutes a still stronger argument against the view of there being any homology between the rod-shaped bases of the Plastron of the Chelonians and those of the Sternum of the higher Vertebrata,—the relation in which the two anterior stand to the "musculi pectorales majores." In Birds, for instance, and the Mammalia, in whom these muscles are formed at about the same time as the two long rods which indicate the commencement of the Sternum; attached at one of their ends to the external surface of these rods, and thus to some extent, at least, lie beneath them. They are also, at first, like the rods themselves, situated at a considerable distance from one another, and in common with them gradually approximate to one another.

On the contrary, in the Chelonians these muscles always lie on the upper surfaces of the rods in question, especially of the anterior pair, and thus exhibit an inverse relation as regards position to that which is met with in the higher Vertebrata. Moreover, in the Marine species, and in *Trionyx*, they are not attached by one extremity to these pieces, but advance to the middle line of the body to a greater or less extent over them, varying with the particular species and the age; consequently, in the Chelonians in general the relation of the great pectoral muscles to the Plastron is neither so intimate, or necessary, as that which they possess to the Sternum in the higher Vertebrata. Hence, as from the grounds I have adduced the original rod-shaped lateral parts of the Plastron of the Chelonians cannot be regarded as equivalent to those portions of the skeleton which constitute the Sternum, neither can the azygous piece of the Chelonian Plastron possess the significance of the Sternum. For the latter forms itself *within* various muscles, and always maintains its place amongst them, like the ribs and other parts of the animal skeleton, whilst the Plastron of Chelonians generally is formed independently of all muscles.

Secondly, the Plastron develops, as has been already fully described, in the subcutaneous connective tissue, and is originally completely concealed within it. For, according to observation made on *Testudo*, and Marine Chelonians, it lies originally, and for a considerable period, so enclosed in the substance of the thick and dense layers which are composed of the subcutaneous connective tissue, that it is entirely invested by them, not only on its upper, but also on its lower surface.

The Plastron thus originates in the same matrix as that in which the accessory (supplemental) plates of the carapace of the Chelonians is formed, and as that in which the bony plates of the skin of many other Vertebrata is developed, as for instance, in the Crocodiles, Sturgeons, and Syngnathidæ (as I can state from my own researches), whilst the vertebræ and the ribs more distant from the surface of the body develop from another kind of matrix. It is obvious from these genetic relations what significance is to be attributed to the Plastron. Like the supplemental plates of the Carapace, it is to be regarded as essentially a portion of the dermal skeleton.

Note.—Hence, I hold that the comparison made by Geoffroy St. Hilaire the elder, in his 'Philosophical Anatomy' (vol. i, p. 106), between the several pieces of the Plastron of Chelonians and the osseous pieces composing the Sternum of Birds is opposed to nature, and wholly fails.

All the original figures in Plate XII (1—9) are from newly hatched young of *Chelone mydas;* fig. 8 shows a transversely vertical section through the anterior lip of the plastron; fig. 9 a little further back, and fig. 7 posterior to it; the last section has cut through the inter-clavicle, the other two through the clavicles only. It is clearly shown that the two laminæ of bony matter are mere calcifications of layers of the skin (c. v.); where these deposits have begun to form a suture by the interlocking of the right and left clavicle (see fig. 9), a third lamina has commenced, and these delicate bony layers have coalesced at this point. The space between the bony laminæ is filled with a softer fibrous stroma than that which forms the corium, and the connective tissue inside the new bone is of a looser texture. These ossified tracts have already taken on very much of their permanent form (see fig. 1, where the relation of the upper surface of the plastron to the Shoulder-girdle is displayed). The two foremost (cl.) form an elegant horizontal arch; the single piece (i. cl.) is nail-like, and its broad end is locked in between and behind the front pair; then come two larger radiating plates (p. t. t.), overlapped in front by the foremost bones. On each side of the umbilicus (u.) there is another pair of many-spurred bones (p. r. a.); and wedged between their hindermost forks there is, on each side, a flat bony plate, pointed in front, and rounded behind (p. t. a.). The *special* names for the three foremost are "clavicles" (cl.) and "interclavicle" (i.cl.); their *general* names are "præ-thoracic" and "inter-thoracic;" the next pair (p. t.) are the "post-thoracic," then the "præ-abdominal" (p. r. a.), and lastly the "post-abdominal" plates (p. t. a.). The Lizards, generally, retain the three foremost of the thoracic plates, and the Crocodilia the azygous piece only; but, as I have shown, the "præ-" and "post-abdominal" plates reappear in the latter but broken up into a series of pseudo-ribs. The form of the interclavicular piece of the Lizard is curiously copied in the Chelonian, but broken up, as it were, the transverse bands appearing in *Trionyx* (Plate XII, fig. 13, i. cl.), and the longitudinal piece (as in the Crocodile) in *Chelone virgata* (Plate XII, fig. 14, i. cl.); in *Sphargis* (figs. 11 and 12) the interclavicle is wanting.

These plates take on an essentially ganoid character in certain Mud-Tortoises (see a figure of the plastron of *Tetrathyra Baikii*, in Dr. Gray's paper "On a new Genus and Species of the Trionychidæ from Western Africa," 'Zool. Proc.,' 1865, part i, pp. 323, 324). In them the interclavicle is V-shaped, and answers to the *arms* of that of the Varanians (Plate X), whilst the clavicles have a "ganoid" disc on their free ends, and the post-thoracic plates have a much larger growth of the same kind.

If we look at the skeleton of the Common Tortoise (*Testudo græca*) we shall see that the endo-skeleton is really very delicate, whilst the dermal ossifications are exceedingly strong, and fit into each other by sharp sutural teeth. Now, if these dermal plates had been broken up into innumerable small disks, as in the Blind-worm (*Anguis fragilis*), and each of these defended externally by its own epidermal scute,—and if we also suppose the limb-skeleton to have been absent, then the Tortoise would have been a mere Snake,—broad-bodied, indeed, and horny faced, but a Snake notwithstanding. The dermal skeleton of the Chelonian is to that of the Anguian or Cyclodont what the ganoid covering of *Callichthys* or *Gasterosteus* is to the outer skeleton of a Fish with smaller imbricated scales or plates, whether "ganoid," "cycloid," or "ctenoid."

Now, if we compare the dermal armour of *Callichthys* (see Plate I, figs. 9—13,) with that of a Chelonian, leaving out of question, for the time, the *borrowed* origin of many of the dorsal and supero-lateral plates of the latter, we cannot choose but see a great correspondence. In *Callichthys* (Plate I, fig. 10), we have the dorsal or spinal plates, then the supero-lateral plates (fig. 9), autogenous in the Fish, but connate with the ribs in the Tortoise.

The marginal (supplementary) plates of the Tortoise are not generally represented in *Callichthys*, but this segment appears on the right side of the Shoulder-region (Plate I, fig. 9, s. cl.); it is the "supra-clavicle." The azygous piece of the Chelonian Plastron does not appear in that form in the Fish—not in any Fish; but in the Shoulder-region we have its true counterpart as a pair of intercalary plates (Plate I, figs. 9, 11, 12 and 13, i. cl.). Certain Fishes have azygous plates on the thoracic-abdominal line; but these, as I have shown, belong to a further breaking up of the dermal system, and are wedged in between the paired "inter-clavicles."

In those ancient relatives of the Chelonia, the *Plesiosaurs*, the azygous bones along the abdominal line are evidently the serial homologues of the inter-clavicle (the so-called "ento-sternum") of the Chelonian.

The Shoulder-girdle of the Chelonian is extremely simple; that of the ripe embryo of Green Turtle is shown in Plate XII, figs. 1—3; the figures are magnified two diameters. If we seek for likenesses to the condition of the parts seen here, we must look backwards to the Amphibia and forwards to one genus of the Bird-class, viz. *Struthio*. In *Chelone mydas* each moiety is merely a forked ray, the bifurcation of which takes place at the middle, at which part there is considerable enlargement, the swollen part being cupped deeply on the outside; this is the glenoid cavity (gl.); the main part is the scapula (sc.); the front fork the præ-coracoid (p. cr.); and the hinder fork the coracoid (cr.). I have given but one instance (*Dactylethra*,

Plate VI, figs. 10—12) in which an Anouran has the præ-coracoid severed from the coracoid by a *notch;* in the other instances there is a *fenestra* in that region; this, however, which is exceptional in the tailless Amphibia, is the unvarying rule in the tail-bearing forms (see Plates III and IV). Again, in the Lacertilia, the "præ-" and "epi-coracoids" are continuous, whilst in the Crocodiles the præ-coracoid is aborted—all but its upper root: in the Chelonian there is no instance, as far as I know, of a closed inter-coracoid space. The form of the scapula (sc.) is very remarkable (Plate XII, figs. 1—3), it is an almost cylindrical rod, becoming flat at the top, where its unossified part is the supra-scapula (s. sc.); the position of this part, in relation to the last certical vertebra is essentially the same as that of the Ray, in that creature related to several cervical vertebræ. There is a difference, however, namely, in the Ray the edges of the supra-scapulæ (see Plate I, figs. 1—4) come close up to the vertebral spine, whilst in the Chelonian they are attached to the spine by a ligament. Their total independence of the small cervical rib (figs. 3 and 4) is shown in the figures, and a very powerful imagination is required to suppose that the scapular rod is here merely a segment of the rib; the dislocation is too violent, and the hypothesis cannot be digested. There is nothing that can be called "præ-" or "meso-scapula," save the swollen part in front, which passes interruptedly into the præ-coracoid (p. cr.); this front fork forms, with the scapula, a gentle arc (see fig. 3); it is of the same thickness, nearly of the same length, and has no separate osseous centre, the two bars being hardened by one *ectosteal* sheath. This anterior bar has been supposed to be the "acromion process;" it is that at its root, but is much more, and in the Anourous Amphibia, and often in the Urodela, has its own osseous sheath. It is still soft below in this young specimen, and the relation of this lower end to the dermal bones is shown in figs. 1, 3, and 7; the more enlarged figure (ten diameters) shows how this soft end of the præ-coracoid is brought into relation with the clavicles and inter-clavicle (cl., i. cl.) exactly as in the Lizards (see Plates IX—XI); it is bound to them by a ligament, but there is nothing except fibrous tissue between these parts. In the Mammal the distal end of the præ-coracoid is developed *autogenously* in relation with the sternal end of the clavicle, and undergoes a peculiar segmentation, as I shall show in due time. The coracoid has its own bony centre (figs. 1 and 2); it is the longest rod of the three, and passes backwards and inwards, ending in a hooked, soft epicoracoid (e. cr.). This part (see fig. 1) reaches to within a short distance of the umbilicus (u.), in the interspace between the post-thoracic and pre-abdominal plates. In some of the Chelonians, especially *Testudo*, the coracoid is a triangular plate, and not rod-like, as in *Chelone mydas;* in the latter type there is a remarkable agreement as to outer form with that of the genus *Dactylethra* (Plate VI, figs. 10—12) amongst the Frogs, and also in the shape of the præ-coracoid, but nothing could be more unlike than the scapula and supra-scapula of these two animals. But the scapulæ of the *Systomæ* (Plate VII, figs. 9, 10), are nearly as narrow as in the Chelonia; the whole Shoulder-girdle of the Chelonia is a forked ray, the anterior fork being ossified continuously with the primary ray (scapula), and the posterior ray having its own ectosteal sheath; this is exactly repeated in the African Ostrich, *Struthio camelus*, see Plate XVII, figs. 5, 6.

BIRDS.

General Remarks.

Once amongst the Warm-blooded Vertebrata, we encounter a host of morphological difficulties, arising from metamorphic changes very analogous to the modifications undergone by Insects as they pass from their *larval* and *pupal* condition into their perfect or "imago" stage.

There are genera, however, both amongst the Birds and the Mammalia, in which but little of this kind of development takes place; the arrested, simple conditions of the Reptilia being permanently retained: these generalised types are the typical Struthionidæ and the Monotremata.

These generalised types and the Crocodiles have the most remarkable morphological affinities, and throw mutual light upon each other. As for Birds in general, it is hard to say which is the most *Reptilian* group; for I have found the most unmistakable Lacertian characters in the noblest aërial types, whilst the Struthionidæ, which undergo the least metamorphosis, come as near to the Mammalia as they do to the Reptilia.

In studying the lower half of the thorax and the Shoulder-girdle of the Bird, I shall "fetch a compass" round the entire class, beginning with the Penguin, and ending with the Ostrich. I do not, however, intend to make merely a "coast survey," but to travel inland also at various points, so as to learn something of the central tribes.

In so doing, I must refer the reader from time to time to the territories we have left behind, and occasionally to that towards which we are led through the various highways and byways of the Bird-class. We might indeed gain the Mammalian Class by a very short route; for we have but to step from the Crocodile to the Ostrich, and from the Ostrich to the Monotreme, and we are landed amongst the creatures that "make their teats naked, and give suck to their whelps;" but this is not the right way, for every finished and noble Bird-type would be left on the right hand and on the left.

The changes that these higher morphological types have undergone are not brought about by the adoption of new structures, nor by leaving out the old, but by *segmentation*, *arrest*, and *metamorphosis;* the "raw material" is taken up again from those larval and pupal types, the Fishes, Amphibians, and Reptiles; but the primordial skeletal masses are *cloven*, *selected*, and brought into new and closer correlation, so that their original Reptilian and Ichthyic conditions have to be sought for in their early and rapidly changing stages. The skeletal regions which have to be treated of here may be clearly characterised in the Bird-class; for Birds in spite of their potency in generic and specific numbers, have, on the whole, much uniformity.

For instance, transverse segmentation of the Shoulder-girdle moiety, which we have lost sight of ever since we left the Fish-class, reappears, and is very constant in the Birds; for, except in the typical Struthionidæ, the scapula and coracoid are always completely cleft asunder. The next character is universal, and it is this, namely, that the supra-scapula is ossified continuously from the scapular shaft-bone, and the epicoracoid from the coracoidal shaft-bone. The præ-coracoid is always segmented from the head of the coracoid, and the "acromion" (meso-scapula) also gives off a segment in typical Birds; neither of these parts are cloven from the common mass in the true Struthionidæ. These segments of the Shoulder-girdle are very apt to be fused with the clavicles, for they often *borrow their earliest osseous deposit* from those subcutaneous splints. In a very large number of Birds the three shoulder-splints are present, forming the *fibrous* part of the "furcula;" but that compound bone *adopts* the cartilaginous segments, as though they originally belonged to it; and from this arises the great difficulty in comprehending its true nature. In some Birds, for instance, the Rails, some of the Zygodactyli, some of the Syndactyli, and most of Striginæ, the clavicles meet without the intervention of the inter-clavicular keystone; but in some Zygodactyles, Syndactyles, and Owls, the clavicles do not unite with each other. In the Struthious genera *Casuarius* and *Dromæus* the small clavicles do not even approach each other; in the other genera they are altogether absent, as they are also in certain Parrakeets, for instance, *Agapornis*, *Melopsittacus*, &c., their supposed clavicular rudiments being ossified "meso-scapular segments." The præ-scapular region is wholly wanting in the Bird, and the continuous meso-scapula (acromion) is very small; the meso-coracoid is often present, and clasps the attenuated upper end of the "middle pectoral muscle," forming a perfect bony ring round it in some instances, by fusing with the head of the coracoid, just as the meso-scapula fuses with the head of the coracoid, thus embracing the "supra-spinatus muscle" in the Unau and the Megatheroids.

These modifications of parts of the Shoulder-girdle, as a correlate of the massive development of certain muscles, greatly masks the homology of the parts.

But the Sternum, the common keystone of the costal arches, is, above all other parts of the skeleton, modified in relation to an inordinate muscular development. The size, both in length and breadth, its outgrowths, its histological consistence, the number of its ossific centres, and, above all, the number of its unfinished *clefts*—all these things conspire to make the study of this part of the Bird's skeleton difficult in the highest degree. My own researches into its nature began twenty-five years ago, and many a struggle have I had with its difficulties, as again and yet again I have returned to it; and even now I have been compelled to seek help[1] in the matter of nomenclature, in this new essay at its explanation.

A well-developed Bird's Sternum may be described as made up of *three* successive regions, as in Man, namely, a "præ-sternal," a "meso-sternal," and a "xiphi-sternal region: this is its primary, transverse, regional division. Longitudinally, it has *five* parallel regions, the middle region being double, in reality; these are the "lateral," "intermediate," and "mesial" regions, or tracts. These divisions are marked in various ways, viz. by their relation to surrounding parts, by their ossific centres, and by their arrested *clefts*. As to the transverse division, there is often a further subdivision to be made out; and this depends upon the formation of "fenestræ," or arrested clefts, tending to cut up the Sternum into succeeding sternal pieces, as in the Mammalia: several membranous spaces, of *no use* to the Teleologist, have this nature, and are a *prolepsis* of what we often find in a finished condition in the highest Class.

The longitudinal division of the Sternum is of much greater importance in the Bird than the transverse, yet it is necessary to keep the latter in view for the sake of comparison with the Mammal. If we examine the Gallinaceous Sternum before the middle of incubation (ninth day)

[1] From Professor Huxley.

we find no bony centres; and the lateral halves are imperfectly united at the mid-line (see Plate XVI, fig. 2, which is that of a Pheasant-chick, magnified six diameters). Five parts are seen in front, namely, the two costal processes (c. p.) externally; the rostrum (r.) at the mid-line,—this is notched in front; and between these a deep notch, bounded, submesially, by the coracoid lips and groove (cr. g.).

The costal processes pass into the costal region, with its four condyles for the sternal ribs (c. c.); behind the fourth condyle the large, lateral xiphisternum is seen, which bifurcates into the "external" and the "intermediate xiphoid processes" (e. x. and i. x.); the interspace between these is the "external xiphoid notch." Between the "intermediate xiphoid process" and the main part of the Sternum there is a very long notch, with only a moderate tract intervening between it and the anterior notch; if these clefts were perfect, we should have a large separate "ento-sternum" (e. s.), with the emarginate rostrum in front, the coracoid grooves antero-laterally, a large keel further backwards, and behind the keel the "middle xiphoid process" (m. x.); this process is double, and its halves are separated by the primordial fissure. I shall describe the smaller clefts, which tend to cut up the great "ento-sternal" mass into successive segments, when I come to the various types; I must, however, speak beforehand of the osseous centres which appear in this great, single, sternal plate, potentially so compound, and yet with no complete cleavage; and although ossified from several centres, yet soon becoming absolutely single, even in that respect. For the Bird's Breast-bone is of a very high morphological type, but extremely unlike that of the Mammal, whose Sternum, often very perfectly segmented, has so little lateral and vertical extension.

The fewest ossifications appear in the Struthionidæ; these, with the exception of the genus *Rhea*, have but one symmetrical pair; these centres being principally related to the costal margin, may each be called "pleurosteon" (see Plate XVII, figs. 3 and 4); they exist in all the Lacertilia and the Crocodiles. In all other Birds, known to me, there is a large azygous centre, which arises in the crest of the Sternum (see Plate XV, fig. 17, l. o.); this may be termed the "lophosteon," it is nearly universal in the Bird-class, but has been observed in no other Vertebrates. Behind each "pleurosteon" there is, in the Gallinaceæ (see Plate XVI, fig. 10, m. o.), and a few other types, in the Crows (see Plate XV, fig. 18, m. o.), for instance, another bony centre, the "metosteon;" it ossifies the outer and intermediate xiphoid bars in the Gallinaceæ; this centre exists in the third degree of frequency.

In the Hemipods (*Turnix*) there is an ovoidal patch of bone on each side the "lophosteon," each piece being about half the size of that centre; these (see Plate XVI, figs. 13, 14, c. o.) may each be called "coracosteon:" it is probable that these may exist in the Tinamous; but they are rare, evidently.

The xiphoid end of the "ento-sternum"—"middle xiphisternal process"—is heart-shaped in the Cariama (*Dicholophus*); it is almost a separate segment, and has in its centre a small bone (see Plate XIV, figs. 11 and 12, u. o.); this rare bone in the tail-end of the ento-sternum may be called the "urosteon." In the genus *Rhea*, besides the pair of centres seen in the other typical Ostriches, there is, on each side, an osseous centre in front of the first rib: it ossifies the costal process, and, projecting forwards as a wing in front of the sternal ribs, may be called the "pro-osteon." These are all the bony centres I have seen in the Sternum of the Bird; the "pleurosteon" appears on each side in the Reptile, and the "metosteon" in the feeble osseous deposit in each xiphisternal horn of *Stellio* (Plate XI, figs. 1 and 2, x. st.) whilst the "pro-osteon" is to be seen, either azygous or symmetrical, in several Mammals. The other centres, however, the "lophosteon," the "urosteon," and the "coracostea," are, I believe, absolutely ornithic, having no counterparts in other Vertebrata than Birds.

The sternal ribs are ossified by ectosteal deposits *at first*, like the vertebral ribs, the only exception being in the Penguins (see Plate XIV, fig. 1); in these Birds the sternal ribs are affected by endostosis first and afterwards by ectostosis. In all Birds, the Penguin not excepted, they become thoroughly ossified very early, and are articulated both to their vertebral counterparts and to the Sternum by synovial joints. There are no "costæ intermediæ" in Birds, and the vertebral ribs develop retral autogenous appendages in all but the *Palamedeæ*. It has been shown that in the Anoura the Sternum in some cases has an ectosteal sheath, as in the Frog; and in others only an internal deposit, as in the Toad (see Plates V—VII). We saw no instance of any outer plate of bone, however, in the genuine Reptiles.

There is great variation in this respect in the Mammalian Sternum, for whilst the Monotremes, Marsupials, Rodents, Insectivores, Carnivores, and Cetaceans, have their sternal pieces ossified as shaft-bones originally, in the other Orders the deposit, even when the ossification is at length very perfect, always appears like an epiphysis at first.

As to Birds, in the Ostrich tribe and in the Gallinaceæ the first deposit is by ectostosis (see Plates XVI, XVII), hence the definiteness of their bony centres; in all the other tribes, as far as I have seen, even in the Pigeons, so near akin to the Fowls, the deposit is *internal* at first, and it is deposited in two layers, with cartilage within and on the outside, as in all the Reptilia proper.

Contrary to what occurs in these latter Cold-blooded creatures, these endosteal tracts grow with extreme rapidity in the Bird, and thus a certain nick of time has to be found in which their distinctness may be seen; moreover, soon after the fast-growing fledgling of an Aërial Bird has taken to its wings the ectosteal layer commences, ultimately giving the bone as complete a *finish* as is seen in the Sternum of the Ostrich and the Fowl.

Family—SPHENISCINÆ.[1]

Example.—Eudyptes ——— ?

The Shoulder-girdle and Sternum of a young Penguin (probably *E. chrysocome*) is figured in Plate XIV (fig. 1, three quarters natural size; fig. 2, twice natural size; and fig. 3, natural size). The scapula (sc.) is very broad, quite unlike what is typical amongst Birds, its suprascapular region (s. sc.) is still soft, as is the glenoid region and the small meso-scapula (m. sc.). The coracoid (cr.) is a very stout rod of bone; its head and its epicoracoid region (e. cr.) are still soft; from its head there proceeds a large falcate segment, the "proximal præ-coracoid" (p. p. c.), which is attached to the antero-external margin of the clavicle, but is at present quite

[1] I here use no particular classification, but place my instances in such groups as seem to be most natural; as to the terms "Order," "Family," &c., I lay no great stress upon them, merely using them for convenience' sake. I must refer the reader to Professor Huxley's forthcoming Paper, in the 'Zool. Proc.,' for his views on the arrangement of the members of the Bird-Class; it was read in on April 11th, 1867.

distinct from it. The meso-scapular segment has been ossified by the top of the clavicle (cl.), and cannot be seen at this stage; the "furcula" is seen to be composed of the clavicles and interclavicles (see fig. 2, cl., i. cl.). The latter bone is a small wedge; the former are strongly arcuate, and are very broad at the upper third. The Sternum (figs. 1 and 3) is still quite soft, but has the permanent form; it is broad above, and gradually narrows downwards or behind; the costal processes (c. p.) are subquadrate and hooked; the coracoid grooves have thick lips, the outer lip being evidently an outgrowth from the inner (see fig. 1), and the right groove is in front of the left (fig. 3). The keel projects in front of the body of the Sternum (see fig. 3), and reaches nearly to the end of the ento-sternum (fig. 1); the latter part is not differentiated from the inner fork of the outer xiphisternum, but ends in a sharp mesial xiphoid process (m. x.). The ento-sternum has no rostrum, the primordial division being indicated by a shallow notch (fig. 3, e. st.). There are six pairs of costal condyles (figs. 1 and 3, c. c.) for the gradually lengthening sternal ribs, and then come the long, narrow, external xiphoid bars, with their hooked and expanded ends (e. x.). The sternal ribs (fig. 1, s. r.) are, as I said before, exceptional; they are endosteally ossified at first, and then acquire an ectosteal sheath. They unite by synovial joints both with the Sternum and with the vertebral ribs (v. r.). Behind the first floating sternal rib there is a free abdominal rib (a. r.), which, like the one in front of it, is at present in the Reptilian stage, having no bony matter on its surface.

Family—" ALCINÆ."

Example.—Uria troile, Linn.

The Old-world Divers that come nearest to the Penguins are very much more typical ornithically than the latter, and belong to a very distinct Family, divisible into several Sub-families, namely, the Alcinæ proper, Colymbinæ, Podicipinæ, &c. My dissections are of embryos of the Common Guillemot, a form differing in nothing essential from *Alca Torda*, and *A. impennis:* I have three stages from the egg, and also the adult. In an embryo at the end of the first third of incubation, and the size of an ordinary filbert, we see what I have figured in Plate XVII, figs. 10—13; figs. 10 and 11 being magnified five diameters, fig. 12 eleven diameters, and fig. 13 fifteen diameters. The scapular shaft-bone (fig. 10. sc.) is not half the length of the whole of the scimitar-shaped bar; it does not nearly reach the base, which is still only separated from the head of the coracoid (cr.) by a notch, (fig. 12, sc. cr.). The coracoid is only half the length of the scapula; but it is much broader, has a dilated head, and a very large hooked (Reptilian) epicoracoid region; both these regions are quite soft (figs. 10 and 12). The meso-scapular segment (m. s. s.) is nearly as long as the coracoid (figs. 10, 12, and 13, m. s. s.), and is already receiving osseous deposit, borrowed from the clavicle (cl.). It is best seen from behind (fig. 13); and then we also observe that the strongly bent clavicle resembles at this stage that of a Teleostean Fish or a Cyclodont Lizard (see Plate X); it is still separate from its fellow, and the "interclavicle" (i. cl.) is forming at the angle. The "proximal præ-coracoid" (fig. 12, p. p. c.) is definable as a wedge of very soft cartilage, between the head of the coracoid and the clavicle. The Sternum (figs. 10 and 11) is well-shaped already, and even now is more typical in form than what is seen in the Penguin; its halves are well united, and the keel (fig. 11, k.) is of considerable size.

The rostrum (r.) is already evident, and the external xiphoid process (e. x.) is differentiated from the middle part (m. x.) by a notch; but there is no fissure between the intermediate and middle xiphoid in this species at any stage. The primordial division of the two halves of the Sternum is shown behind; and the xiphoid region, altogether, is small—only half the length of the Sternum, and very narrow. Seven pairs of sternal ribs have synovial joints with the Sternum, and an eighth pair nearly reaches its edge. In Plate XVI, fig. 23, the position of the three clavicular bones at the next stage, as seen from behind, is shown, magnified twenty diameters; the clavicles (cl.) are united by suture, and beneath them is the inter-clavicle (i. cl.); whilst the soft and very transparent tissue, in which it is imbedded, is the feeble rudiment of a right and left pair of distal præ-coracoids, a structure well developed in many Mammals. The most important change to be noticed in this further stage, when the embryo is twice the size of the one last described, is the formation of a delicate mass of fibro-cartilage, the "distal præ-coracoid" (d. p. c.), in the middle of which the inter-clavicle, now very distinct, can be seen. In an embryo three or four days before hatching (see Plate XVII, fig. 14, which is magnified three diameters), we find several things to be noticed; and these are the advance of the ossifying shafts; the more perfect fission of the scapula (sc.) from the coracoid (cr.); and especially the forward elongation of the head of the latter, on which the proximal præ-coracoid (p. p. c.) is well seen, as a thick wedge of clear cartilage, as yet quite distinct from the clavicle; this latter part, however, has quite used up the meso-scapular segment, and the soft tissue below has been ossified by the inter-clavicle (i. cl.). The whole form of the "furcula" is more like what is seen in the adult; and so is that of the true Shoulder-girdle. The rostrum of the Sternum (r.) is now well developed; but both it, the rest of the Sternum, the sternal ribs (s. r.), and the costal appendages (a. p.), are all unossified, as is much of the vertebral ribs (v. r.), especially behind. The keel (k.) is now growing forwards under the rostrum, and the external xiphoid process (e. x.) has attained its proper shape; whilst the post-costal part of the Sternum is relatively larger, and the meso-xiphoid notch is filled up behind. The eighth sternal rib reaches the Sternum in this instance; then comes another which reaches nearly as far downwards, and after it there is an abdominal rib (a. r.) which, however, has *a distal* vertebral portion; this well illustrates the lateral deficiency of cartilaginous arches, and how they crop out below. The costal appendages (a. p.) are curious rays, growing out of and segmenting themselves from the vertebral ribs; there are eight pairs of them, and they have very fanciful shapes. The bony structures of the Shoulder and Sternum in the adult can now be understood (see 'Osteol. Catal. Hunt. Mus.' vol. i, p. 223, No. 1164).

The scapula is very long and narrow, and is blunt-pointed; the coracoid is strongly hooked in front, and the præ-coracoid segment, which articulates with the flattened end of the hook, is thus carried far from the shaft. The meso-coracoid region is defined by an inferior groove, and by the large coracoid foramen; the epicoracoid region sends upwards a small sharp hook. The præ-coracoid segment is one with the furcular ramus (clavicle), and reaches to the most curved part of the strongly bent bar; this bar thickens where it curves inwards to meet its fellow. Behind the junction of the two clavicles the inter-clavicle grows backwards as a notable semi-oval plate. The Sternum is long-oblong—very long indeed, and is only a little narrow behind the last sternal rib; this rib only marks the end of the first third of the Sternum. The rostrum is large and well marked; the keel runs far forwards; the external xiphisternal process is separated by a narrow long notch from the intermediate and middle part, which have no cleft between them. The posterior margin of the Sternum, however, is trilobate, showing its triple nature, and it is not thoroughly ossified. Opposite the sixth sternal rib there is, in the specimen in my collection, on the left side, an oval "fenestra," an arrested cleft between the ento-sternum and the costal region; and all along this region there are large patches of bone deprived of diploe, showing a tendency to split up into parallel bands.

In *Uria grylle* (see Owen, 'Trans. Zool. Soc.,' 1865, vol. v, pl. 52, fig. 14) the Sternum is much wider in the external xiphoid region; and there are two small fenestræ—one space divided by a periosteal band—on each side, showing the boundary line between the "intermediate" and "middle xiphoid" regions. In *Alca impennis* these spaces are obsolete (see fig. 1 of the same plate), and in *Alca Torda* (in my specimen) the short ensiform "external xiphoids" are separated by a notch from the middle part, whilst on the right side there is a small fenestra between the intermediate and inner regions. In the specimen in the Hunterian Museum (No. 1146) there is no sub-mesial fenestra, and the outer notches are walled-in, having either become fenestræ in old age, or having been so from the first. In *Fratercula arctica* (No. 1161) the outer clefts are merely two minute foramina on the left, and one small hole on the right side; the inner spaces are much larger, and are *fenestræ;* behind these arrested clefts the Sternum is narrower, but then sends out two small ears, and terminates in a large semi-oval spoon-like plate.

The Colymbidæ (see Hunt. Mus., No. 1165) differ much from the Alcidæ, for the scapula is relatively much shorter, and the coracoids altogether larger; the meso-scapula is blunter and smaller, and the meso-coracoid is a delicate curled flap of bone, separated by a deep notch above from the main part. The "præ-coracoid segment" is not developed, and the furcular rami are very flat and thin; their principal curve is at the lower third; the inter-clavicle is small. The rostrum of the Sternum is much less pronounced than in the Alcidæ, and the keel is less developed at its angle; it also dies out sooner behind, and is less deep. The whole Sternum is broader and much more scooped; the external xiphoids are narrow, being separated by a deep notch from the main part; this has no very distinct sub-mesial fenestra, but in *C. septentrionalis* the broad, flat, abdominal part is notched feebly on each side, and is full of small holes; this is like what is seen in the coracoid of the Herring (see Plate II, figs. 4, 5), where the cleavage is broken up into many spaces.

Family—PODICIPINÆ.

Example 1.—*Podiceps minor,* Gmel.

These Birds agree in many respects with the *Colymbi,* but they are not unrelated to the Cormorants. The Sternum of the small kind, the Dabchick, is shown of the natural size in Plate XIV, figs. 4, 5, as seen from above, and laterally. There is no rostrum, and the keel (k.) does not project much forwards; the coracoid grooves (cr. g.) are wide apart, and a rounded (primordial) notch separates them; behind, there is a larger amount of this original divisional space. The costal processes are triangular; the costal condyles are six in number on each side; the external xiphoids are long and elegantly bowed; they are separated by a large semi-oval notch from the intermediate xiphoid, which, in its turn, is but feebly marked off from the short and somewhat arrested ento-sternum. There is generally some unossified cartilage behind, and the bone is extremely thin at that part; on the whole, this is one of the most arrested types of Sternum to be seen in the whole Class, and differs very widely from that of the Colymbidæ and Alcidæ. The coracoids lack the meso-coracoid hook, or it is a mere rudiment; the furcula has narrow and less curved rami, and the inter-clavicle is very small.

Example 2.—*Podiceps rubricollis,* Gmel.

The want of symmetry so frequently seen in the costal arches of Birds is well shown in this species of Grebe. Plate XI, fig. 11, shows the last perfect sternal rib and part of the vertebral rib of the left side (sr., v. r.); behind these is the first " floating rib;" then comes an abdominal rib (a.r. 1), which mounts up into the vertebral region, but without subdivision, and behind it there is a smaller bar (a. r. 2), which is dilated above. On the right side (fig. 10) there is only one abdominal rib (a. r.), which has, however, the rudiment of another near its upper end. I have had these parts drawn on the same plate as those of the Chamæleon, for the sake of comparison; the skeleton which shows them was made and drawn by me many years ago, and is now in the Hunterian Museum.

Family—PELECANINÆ.

Example 1.—*Phalacrocorax* ——— ?

My young specimens of Pelecanine Birds[1] are from *Guano,* brought from the Chincha Islands; they are Cormorants and Boobies. The Shoulder-girdle and Sternum of the youngest of the Cormorants is shown in Plate XIII, fig. 3 (natural size), as seen from below.

The scapulæ (sc.) are sword-shaped, straight, narrow—most so at the middle, and pointed at the ends; their supra-scapular end is soft, as is also the acromion and glenoid region (gl.). The coracoids (cr.) are phalangiform rays with swollen heads and hooked (epicoracoid) bases; these are still soft, and so is the præ-coracoid bar (p. cr.): this latter part is a large cartilaginous wedge, with its flat end downwards, and its inner face in close contact with the clavicle (cl.). This last is a sinuous, flexible rod, pointed above, then broader, and rounded below, where it meets with its fellow, and forms a V-shaped "furcula," having a small inter-clavicle (i. cl.) at their point of juncture behind: all these have already coalesced together. The Sternum has acquired much of its permanent form, but it is still entirely unossified, and it has many embryonic characters. The coracoid grooves (cr. g.) are wide apart, and there is no " rostrum " between them; the keel (k.) is small, thick, and undeveloped anteriorly, so that it does not reach nearly to the front of the Sternum. The costal processes (c. p.) are short and rounded, they are followed by five costal condyles for the sternal ribs (s. r.); the fifth of these is imperfect, and the rib becomes a "floating" bar afterwards (it belongs to the second sacral vertebra), and is followed by an abdominal rib; they are almost entirely ossified already by ectostosis. The whole costal region is one third longer than the xiphisternal, instead of being only two thirds, as in the adult; this latter part widens gently, and posteriorly, is elegantly crenate, and the points between the shallow notches are the external (e. x.), the intermediate (i. x.), and the middle xiphoid (m. x.); the two latter do not reach quite so far backwards as the outer process. Altogether, the Sternum is

[1] The gift of T. J. Moore, Esq., of Liverpool.

very square, the length being but little greater than the breadth. The figures showing the next stage (4—6) are reduced one fourth below the natural size; fig. 4 shows the Sternum from above, fig. 5 from below, and fig. 6 the Shoulder-girdle. The osseous shafts of the scapula (sc.) and coracoid (cr.) are considerably advanced, and the proximal præ-coracoid segment (p. cr.) is very much larger, and has acquired a bony mass within; a section of this mass is shown in fig 9, magnified three diameters; *c.* is the outer cartilage, and *en. o.* the endosteal deposit. The shape of the Sternum (figs. 4, 5) has become considerably changed; a small rostrum (r.) has been developed from the top of the now far-projecting keel (k.), and the external xiphoid process (e. x.) has grown backwards into a flat, beak-shaped flap, almost aborting the intermediate process (i. x.); whilst the middle process (m. x.) is well defined, but shows the Reptilian character of the Sternum by its ending so far in front of the outer part. The ear-like costal processes (c. p.) are much more developed, and so are the costal condyles (c. c.); the fifth is aborted. The coracoid grooves (cr. g.) now overlap each other, the right passes below the left, and the furcular angle (cl. i. cl.) articulates with the projecting end of the sternal keel; this crest only occupies the anterior half of the Sternum. A large bilobate tract of bone has appeared in the body of the Sternum, on each side; this is the "pleurosteon;" it is principally internal—entirely at first, but is reaching the surface in its mid-region. The pleurosteon is more developed above (fig. 4) than below (fig. 5), where the right and left tract are still far apart. The keel (k.) is the subject of another bony deposit—the "lophosternum" (l. o.); this commenced in the thickness of the cartilaginous ridge, near its anterior margin. Fig. 7 shows a section (three diameters) taken in a vertically transverse direction through the coracoid grooves; the bony matter (p. o., l. o.) is seen to be almost entirely *within* the cartilage; the "centres" are far apart. Fig. 8 shows a similar section taken in front of the last; there the deposits have begun to meet, and the "lophosternum" (l. o.) has gained the outer surface.

In the adult Cormorant all the parts become intensely ossified, and the præ-coracoid completely coalesces with the clavicle; the Sternum is one dense bone, which, however, retains some soft cartilage behind, both at the mid-line and at the end of the external processes. The keel projects an inch in front of the coracoid grooves; it dies out behind, the part behind the last costal condyles being as much rounded as in the Ostrich's Sternum. One marked peculiarity in the Shoulder-girdle of the Cormorant is the very great length of the scapula, coracoid, and furcular rami, in proportion to that of the Sternum; and another is the sudden angle at which the lower part of each furcular ramus is bent upon itself at the lower third of the præ-coracoid; it is less than a right angle, and the space for the penniform "middle pectoral muscle," which is formed by the thick præ-coracoid above, the coracoid behind, the clavicle in front, and the sternal keel below, is widely oval. The line of segmentation between the head of the coracoid and the great "præ-coracoid segment" has become a large, oval, *gliding* synovial joint.

Example 2.—*Sula fusca,* Viell.

Figs. 10—12 show the Shoulder-girdle of a young Booby reduced to one fourth below the natural size. The supra-scapula (s. sc.) is at this stage like what is persistent in the Reptilia, namely, it is ossified by endostosis only; but this was derived, evidently, from the scapular shaft—was not independent. The coracoid (cr.) is almost entirely ossified, and so also is the præ-coracoid (p. cr.); but this latter bone is still distinct from the clavicle (cl.); it projects considerably *in* *front* of that bar (see fig. 11, cl. p. cr.), but does not reach the top (see figs. 10—12). The Sternum in the genus *Sula* (*e.g.* in *S. bassana*) is much longer in proportion to its width than that of the Cormorant; but in all essentials it agrees with it. In *Pelecanus onocrotalus* the scapula is very narrow, more curved than in the Cormorant, and is very small in comparison with the coracoid, which is very large and hollow. The præ-coracoid is of an extraordinary width—beyond that of any other Bird, and it gives a very peculiar character to the clavicle, with which it is entirely anchylosed. The angle of the "furcula" is but little enlarged by an "inter-clavicle;" it articulates by a flat surface with the angle of the sternal keel. The Sternum is as short as that of the Cormorant; it has five pairs of costal condyles, and its xiphoid region is merely trifid, the "intermediate" processes being undistinguishable; the external processes are very narrow, and do not reach so far backwards as the middle part.

In *Fregata aquila* the Shoulder-girdle is quite similar to that of the Cormorant; but its bars are very long as compared with the Sternum, which is, relatively, the most square, and the shortest I am acquainted with; its posterior margin is sinuous; five projections, severed by four shallow notches, being distinguishable. This Sternum is almost precisely like that of the nestling Cormorant (Plate XIII, fig. 3); but this arrested condition is combined with a perfectly unique condition as to anchylosis, for the furcula coalesces with the sternal keel and with the coracoids; the former condition is to be seen in other Birds, e. g. *Secretarius;* the latter is interesting in a morphological point of view, for the thick part of the furcula is largely derived from the coracoid originally, and parts segmented from one another in the embryonic stage are very apt to coalesce in the adult.

Although the Shoulder-girdle and Sternum of the Pelecaninæ have nothing in them essentially different from what we have seen in the Reptile, yet they are altogether ornithic, and differ very little from what is seen in the highest arboreal Bird-types.

My space does not permit any illustrations of the large Family of the Lamellirostres, but I shall describe them in a few words, and refer the reader to the specimens in the Hunterian and British Museums. My own collection contains all those of which I shall speak, with the exception of *Cygnus musicus* and *Anseranas*.[1] I shall include the Palamedeas, with their arrested horny lamellæ, and exclude the Flamingoes, which, although possessed of these lamellæ, and rich in Anserine characters, belong to the Ibidine division of the Family Ardeinæ.

[1] To be seen in the British Museum.

Family—" LAMELLIROSTRES " *vel* " ANATINÆ."

1*st Sub-fam.*—" PALAMEDIINÆ."

Example.—*Chauna chavaria*, Linn.

2*nd Sub-fam.*—" ANSERINÆ."

Example 1.—*Anser palustris*, Flem.
Example 2.—*Anseranas melanoleuca*, Lath.
Example 3.—*Cygnus olor*, Gmel.
Example 4.—*Cygnus musicus*, Bechst.

3*rd Sub-fam.*—" ANATINÆ."

Example 1.—*Anas boschas*, Linn.
Example 2.—*Querquedula caudacuta*, Ray.

4*th Sub-fam.*—" FULIGULINÆ."

Example 1.—*Oidemia nigra*, Linn.
Example 2.—*Clangula chrysophthalma*, Steph.

5*th Sub-fam.*—" MERGANSERINÆ."

Example 1.—*Merganser castor*, Linn.
Example 2.—*Mergus albellus*, Linn.

If we take these instances of the Lamellirostral Family as fairly representing the whole group, their Shoulder- and Breast-bones may be characterised as follows:

Scapula long, narrow, curved, blunt-pointed; the acromion (meso-scapula) short and rounded.

Coracoid moderately long, with a projecting head; a short, curved meso-coracoid process; a broad epicoracoid region, with the posterior process obtuse, as a rule, but somewhat hooked in the marine species.

Furcula U-shaped, very strong, especially in the terrestrial and fresh-water kinds; pointed at the tips of its rami, and yet having these extremities thickened by the meso-scapular segments; a præcoracoidal spur on the front edge, just below the junction with the head of the coracoid; inter-clavicular process absent, or very rudimentary, or, very rarely, large. The rami of the furcula are strongly curved—the former one third of a circle, and the meso-scapular and præcoracoidal additions are evidently ossified from the clavicles, and not by an autogenous deposit of bony matter.

Sternum large, oblong, moderately broad; costal processes moderate; the keel not reaching the hinder end, and rather deep, deepest in the terrestrial forms, which have its front part projecting but little forwards, whilst it is very projecting as we arrive towards the Mergansers; coracoids not overlapping, but some little distance apart; rostrum absent at both ends of the series, viz. in *Palamedea*, the *Fuligulinæ*, and the *Merganser*; and short, thick, and Pluvialine in *Cygnus, Anser*, and *Anas*; but elongated and Ardeine in *Querquedula caudacuta*. Post-costal region bowed out very little in *Palamedea*, but the width of the hinder half increasing as we pass downwards in the following order, namely, *Palamedea, Cygnus, Anser, Querquedula, Anas, Merganser, Oidemia, Mergus, Clangula.* The hinder part of the Sternum has only three divisions; and these divisions are dilated at the free ends in the marine kinds, viz. *Clangula, Merganser, Mergus,* so as to enclose the great "notch" which divides them on the right and left side, and by an excess of ossification causing the notch to become a "fenestra."

The notch is deepest in the land and fresh-water species, with the exception of *Anseranas,* which makes some approach to the Gruinæ. The broad middle xiphoid plate is nearly an inch shorter than the outer bars in *Palamedea,* one third of an inch shorter in *Cygnus olor* and *Anser palustris;* one eighth of an inch shorter in *Querquedula caudacuta* and *Oidemia nigra;* as much longer in *Anas boschas;* about the same length in *Anseranas;* two lines longer in *Mergus;* and three lines longer in *Clangula chrysophthalma* and *Meganser Castor;* but it is most developed in *Harelda glacialis.*[1] There are eight costal condyles on the left and seven on the right side in *Chauna,* eight on both sides in *Cygnus olor,* seven on both sides in *Anser palustris, Anseranas melanoleuca, Querquedula caudacuta,* and *Oidemia nigra;* six on both sides in *Clangula chrysophthalma, Mergus albellus,* and *Merganser Castor.* The vertebral ribs have well-developed "appendages" in all but *Palamedea,* in which they are entirely absent—a unique state of things. The sternal keel in *Palamedea* does not reach the junction of the coracoid grooves by half an inch, and ends nearly two inches in front of the termination of the outer xiphoids. The coracoids in this Bird are extremely hollow, opening by a large pneumatic foramen above the base and the furcula is absolutely unique as to solidity, the rami being seven lines across and three lines thick at the middle; they diminish in size but little at the angle, and have no azygous part. Next to this comes the furcula of *Anseranas,* which is extremely solid, and has a massive inter-clavicular part, almost reaching the pointed angle of the very deep sternal keel. This last kind of Goose is more nearly related to the Cranes than any other of its tribe; but there is a curious conformity between the Geese and the Cranes in many respects,—namely, in the manner in which the Sternum is hollowed out to receive the trachea, as in *Cygnus musicus, C. Bewickii,* &c., on the one hand, and in *Grus* proper on the other; also in the semblance of a newly hatched Crane to a stilted Gosling; and in the flight of the Geese and Cranes being performed by their flocks in the same kind of military dispositions.

Family—"PROCELLARINÆ."

Example 1.—*Diomedea exulans,* Linn.
Example 2.—*Procellaria capensis,* Linn.
Example 3.—*Pelecanoïdes urinatrix,* Gmel.
Example 4.—*Puffinus brevicaudus,* Brandt.

Family—"LARINÆ."

Example 1.—*Gavia ridibunda,* Linn.
Example 2.—*Rissa tridactyla,* Linn.
Example 3.—*Larus argentatus,* Gmel.
Example 4.—*Sterna nigra,* Linn.
Example 5.—*Thalasseus poliocercus,* Gould.
Example 6.—*Glareola torquata,* Temm.

[1] Professor Newton informed me of this fact with regard to *Harelda.*

I shall speak of the Shoulder-bones of these two great Families together, for they are intimately related, and both have one common origin, namely, in the simple Pluvialine type. When I have described the structure of these oceanic modifications of the Plover, I shall describe the development of the parts in the simple, radical type, and then pass on to the nobler forms of wading and running genera that grow from the same root (see 'Trans. Zool. Soc.' 1863, p. 149). The Albatross and its relatives show the Pluvialine type in its greatest degree of oceanic modification; whilst the Larinæ are directly connected to the Plovers by *Glareola*. In *Diomedea exulans* the scapula is long, very narrow, and much curved; but the coracoid has a perfectly Lacertian expansion; this is seen also to a less degree in *Procellaria capensis*, and in *Puffinus brevicaudus;* in *Pelecanoïdes* it is much narrower. In all these the meso-coracoid is well developed as a curled spur, and the "foramen" is pierced through solid bone. The rami of the furcula are as curved in *Puffinus* as in the Gulls, and it has the same development of the "præ-coracoid;" but this part is less developed in the more typical Petrels, and the rami are straighter. In *Puffinus* the angle of the furcula is free of the Sternum, and has a well-shaped inter-clavicle; but in the others this last part is more or less aborted—especially in *Pelecanoïdes*, and the angles of the furcula and sternal keel are articulated together by a synovial joint. The Procellarinæ agree in having a small rostrum to the Sternum; the coracoid grooves are some distance apart; the keel is strong, broad, and flat below, apiculated at its apex, and reaching nearly the end of the mid-sternum. The costal processes are sharp, and are followed by five or six condyles; the whole shape of the Sternum is squarish and broad; longest in *Pelecanoïdes*, but little expanded between the ribs in *Procellaria capensis* and *Puffinus;* considerably widened in *Diomedea*, and very much so in *Pelecanoïdes*. The xiphoid processes agree with those of the Gulls in *Puffinus*, that is, they are five in number, separated by large semioval notches; and the intermediate bar is only half the size of the outer. In *Procellaria capensis* there is this difference, namely, the notches are small, and consequently the processes are short. In *Diomedea exulans* the middle xiphoid is short and trifid; the intermediate and outer parts form one large flap, separated by a semicircular notch from the middle part, and have a sub-lateral fenestra on the right, and a minute notch on the left side. In *Pelecanoïdes*, with its longer Sternum and elegantly dilated xiphoid region, there is only a slight emargination at the mid-line, and a gentle sinuosity on each side of this notch; there is no other notch or fenestra in the adult, but there are two large fenestræ in the young: the broad outer xiphoids are not ossified behind. The middle part of the Sternum is most arrested in *Diomedea;* but it is greatly expanded in front in that genus.

One description will serve for the six types of Larinæ mentioned above. The ensiform scapula is considerably curved, and its acromion is blunt; the coracoid is elegantly phalangoid; has a large head, and a large flat meso-coracoid, which nearly forms a ring with the head of the bone; the foramen is pierced in solid bone; the epicoracoid region is moderately broad, and there is a delicate upturned hook. The furcula has well-marked thickenings derived from the meso-scapula and proximal præ-coracoid segments; its rami form a third of a circle in their curve; they are strong, oval in section, and have at their angle a semioval interclavicle, which does not reach the sternal keel. The Sternum is a neatly oblong bone, one third longer than broad; its keel is deep, and the apex is produced forwards, whilst its posterior part reaches the end of the middle xiphoid. The rostrum is large and semioval; the costal processes rather square and large; there are six condyles in *Rissa*, *Gavia*, and *Glareola*, and five in *Larus argentatus*.

The xiphoid region soon widens behind the condyles; each process is somewhat expanded, or pedate, and is often soft at its edge. The middle process is the largest; the outer next, and the intermediate bar is very narrow: the outer notches reach more than a third of the distance from the end of the Sternum to the last costal condyle. In *Thalasseus poliocercus* (see Plate X, fig. 11; and 'Osteol. Catal. Hunt. Mus.,' vol. i, p. 232, No. 1238), the anteriorly produced part of the sternal keel is partly separated by a kidney-shaped fenestra (e. s. f.) from the rest of the keel; to this half-severed segment the three furcular bones are attached (fr.). Plate XVI, fig. 24, shows one ramus and part of another of the furcula of *Larus argentatus* from the egg, at the middle of incubation; it is magnified ten diameters. The meso-scapular and proximal præ-coracoid segments (m. sc. s., and p. p. cr.) form one rod of soft cartilage, constricted at its middle, and undergoing ossification from the clavicle (cl.), which is penetrating it like a roughly pointed nail. The inter-clavicle (i. cl.) is seen below, it is very small, and is imbedded in a mass of soft fibro-cartilage (see fig. 25, magnified thirty diameters); whilst the clavicles themselves are uniting, in a sinuous manner, above it. The soft tissue (d. p. cr.) in which the inter-clavicle lies, is the distal præ-coracoid of both sides; it is in a very rudimentary condition, and is soon lost by being converted into the substance of the inter-clavicle.

The Pluvialinæ may be arranged as follows, viz.—

Family.—"PLUVIALINÆ."

1*st Sub-fam.*—"PLUVIALINÆ proper."

Examples.—*Œdicnemus crepitans*, Temm.; *Vanellus cristatus*, Temm.; *Charadrius hiaticula*, Linn.; *Hæmatopus ostralegus*, Linn.

2*nd Sub-fam.*—"TRINGINÆ."

Examples.—*Tringa cinclus*, Linn.; *Recurvirostra avocetta*, Linn.; *Himantopus melanopterus*, Temm.; *Numenius arquata*, Lath.

3*rd Sub-fam.*—"SCOLOPACINÆ."

Examples.—*Scolopax gallinago*, Linn.; *Scolopax gallinula*, Linn.

4*th Sub-fam.*—"PARRINÆ."

Example.—*Parra jacana*, Linn.

I have purposely included in the Pluvialine Family a very large number of Grallatorial genera; some with long and others with short bills; and also the long-toed Jacanas, which are manifestly Pluvialine, having much less relationship to the Rails than to the Plovers. I have already spoken of the Pluvialine characters to be seen in the Gulls and Petrels; these are to be found, although more masked, in the Alcinæ; and as we ascend to many of the nobler Land-tribes, we shall still find that the Plover has to be our starting-point.

In the list of examples given above, *Œdicnemus* is aberrant, having begun to take on characters belonging both to *Otis* and to *Grus; Himantopus* also has the completely open inter-orbital space of *Eurypyga;* and the Jacanas look towards the Rails on one hand, and to the

Palamedeas on the other. But the true *Charadii* and *Tringæ* are of the highest importance to the morphologist, as they evidently are the *radical* or embryonic types, from whence we may conceive whole groups of Amphibious and Water Birds to have arisen by special modification. The Pelecaninæ seem to be another fundamental group, and perhaps the Rails also; but of this I am doubtful, for they have strong marks of belonging to a derived type.

Both in the skull and in the structure of the thorax the typical Pluvialinæ present very important permanent characters; and these characters are either lost or modified in the metamorphosis which the *derived* types undergo. They are but little removed from what is typically Struthious in the characters of the skull; but to these new ones are superadded, for instance, the large "lateral occipital fenestræ," and the more or less perfect *transpalatine* angle to the palatine bone; the perfectly ornithic maxillaries, which, however, do not meet at the mid-line; and the typical development of the "basi-temporals" and eustachian grooves. So that, as to the skull, the Pluvialines are very much more typical than the Struthionidæ; yet they nevertheless keep in a very embryonic condition throughout their life. The Shoulder-girdle and Sternum of the Pluvialinæ are typically ornithic; but these parts are not modified to the same extent as in the surrounding and, as it were, nobler types. I am able to give the condition of the Shoulder-girdle of *Vanellus cristatus* at the end of the first third of the incubating period, before it has lost the whole of those simple characters which are persistent in the Ostriches, and the Sternum of the same embryo which is in a much less advanced stage than that which is persistent in the Ostrich-tribe (see Plate XV, fig. 1, magnified seven diameters; figs. 2 and 3, twenty diameters). The scapula (sc.) and the coracoid (cr.) are bent on each other at an obtuse angle; the bony shaft of each invests about a third, in the middle, and a cleft has appeared opposite the glenoid cavity (gl.); neither of these bars have the elegant form of the fully formed bones; they are more outspread and Reptilian. The meso-scapular and præ-coracoid segment form one piece of soft cartilage constricted at the middle (see figs. 1 and 3); a delicate bony bar, the clavicle (cl.), is creeping into this mass above, and below has commenced to coalesce with its fellow (see figs. 1 and 2, cl.); the interclavicle cannot be traced at this early stage. The Sternum is in a most instructive condition; its structure is softer than that of the Shoulder-girdle, and its two halves have not united; in front we see how the anterior sternal "notch" is formed; and behind we have the long "xiphisternal horns" (x. st.). The keel has not begun to form, and all the "rostral" region is absent, as also the "middle and intermediate xiphisternals." The six sternal ribs are not segmented off close to the sternal margin, but at some distance; and these sternal pedicles become converted into the transverse, elevated condyles. The coracoid grooves (cr. g.) are in the very best stage for the confutation of all transcendentalism with regard to the Shoulder-girdle. The inner lip is wholly within the epicoracoid flap, and the sigmoid outer lip is seen to be far behind it, and to be merely a ledge-like outgrowth, which grows forwards and outwards to abut against the embracing epicoracoid. The epicoracoid keeps its primordial relation to the inner lip of the groove, and becomes underlapped by the outer lip; thus, also, the sternal keel, as an outgrowth, comes to be *external* to the Shoulder-girdle. But the sternal ribs are here caught in the very act of breaking away from their *common* outspread terminal plate—the sternal moiety; they are thus related to the Sternum necessarily; and if the *somatomic* differentiation had been more potent, the Sternum would have been composed of succeeding segments from the first: all its *after-attempts* at subdivision are feeble in the Bird; not so in the Mammal, however.

The ossification of the Sternum in the Pluvialinæ is by three *endosteal* patches—a right and left "pleurosteon" and a "lophosteon;" the latter bony centre, in *Œdicnemus* (six weeks old), is shown in Plate XVI, fig. 22, magnified twenty diameters. The bony deposit (en.) is seen to be in two layers, between which there are irregular marrow cavities (*m. c.*) : *c.* represents the cartilage which is being metamorphosed, and *p.* the perichondrum.

The Shoulder-girdle is very uniform throughout the whole of the large Pluvialine family; the scapula is ensiform, moderately curved, flattened towards its pointed end, and has a blunt meso-scapular process. The coracoid is relatively short, has a projecting head, and a large curled meso-coracoid process, at the root of which is the usual foramen; a narrow, flattened body, a very arcuate articular base, and a well-developed epicoracoid hook. In many species, namely, *Vanellus*, *Œdicnemus*, and *Numenius*, there is an inner epicoracoid process, the distal portion of the arrested meso-coracoid bar. The furcula is U-shaped, strong, has its rami curved to about one third of a circle, and its tips and shoulders thickened by the hourglass-shaped coraco-scapular segment (see Plate XV, fig. 3, m. sc. s., p. cr. s.). These are, however, evidently ossified directly from the clavicles. The interclavicle arises from behind the clavicular synostosis; it is moderately developed, thick, and semi-oval. The Sternum is also very uniform, on the whole; it is oblong, the length being about thrice that of the width; it is widest in *Hæmatopus*, and narrowest in *Totanus*, *Vanellus*, and *Scolopax gallinago*. The outer margins are pinched in a little behind the ribs, and then expand gently. There are, on an average, six pairs of condyles for the sternal ribs, and these run far up the squarish costal processes. The coracoid grooves are separated in front by the thick-topped, semi-oval, well-developed rostrum; in *Œdicnemus* the grooves overlap slightly above the rostrum. The lips of the grooves are unequally developed, the lower always keeping in the rear of the upper, which is in harmony with their nature as secondary outgrowths. There are four oval xiphoid notches, the outer being much the largest; and five xiphoid processes; of necessity the intermediate bars are short, and in *Vanellus* and *Œdicnemus* they unite with the middle process so as to convert the original notches into fenestræ. In the latter Bird the outer bars do the same, and the inner fenestræ become broken up into two, one of these often becoming obliterated on one or the other side. In *Parra jacana* and *Scolopax gallinago* the inner notches are absent; they may have existed, however, in the embryo. The outer xiphoid bar of *Œdicnemus* reaches the end, or nearly so, of the Sternum; it stops sooner in *Vanellus*, but in most it ends considerably in front of the middle and intermediate bars. This condition is best seen in *Numenius* and *Totanus*, and here we get close to those *generalised* Birds the Sand-grouse (Pteroclinæ), which lie but little above the Ostriches, underlie the Pigeons, and have much of the Plover in them (see 'Trans. Zool. Soc.,' 1864, vol. v, part 3, pp. 190—205). The keel of the Sternum is very large in all; it reaches the end, or only flattens out a little near the end of the middle xiphoid bar. In front it retires a little below the rostrum, and then projects elegantly at the angle: this part does not unite with the furcula. Behind the thickened upper coracoid lips there is a deep fossa, which, in Birds with a pneumatic Sternum, would be the air-passage of the keel. Here it shows itself to be merely a remnant of the primordial divisional line of the bone. The upper surface of the Sternum is very hollow; the bony substance, like that of the rest of the skeleton, is thin, horny, and fatty, and thus has altogether a primordial character.

Family—"OTINÆ."

Example.—*Otis tarda*, Linn.

The Bustards are gigantic Plovers, with massive bodies that suggest relationship with the large Gallinæ; this, however, is *isomorphic* and illusory. Like the *Œdicnemus*, they have the "anterior pterygoid processes," which exist in nearly all the simple Pluvialinæ, aborted; and this arrest of fundamental parts is combined in the Bustard with a modification of the furcula which carries them equally away from the Plovers and the Fowls, for the interclavicle is absent or reduced to an unappreciable rudiment, whilst the rami have scarcely any trace (as in *Œdicnemus*) of the upper pre-coracoid rudiment. These united clavicles, moreover, which are becoming broader in the Thick-knee (*Œdicnemus*), are very straight and broad in the Bustard, and the whole bone is much like that of the *Palamedea*, save that in the latter Bird the rami are of unusual thickness. Another character by which the Otinæ recede from both Fowls and Plovers is the abortion of the sternal rostrum; the keel, moreover, retires, as in the Turkey, and is not very deep; its four notches and its five xiphoid processes are typically Pluvialine. The large wings and the perfectly distinct dorsal vertebræ, besides many other characters that could be mentioned, all go to show that these Birds are merely huge terrestrial Plovers—one culminating branch of the genealogical tree of that family; not ready to grow into another Land-type, but having, perhaps, in some remote age, one common ancestry with the Gallinaceous Ground-birds.

Family—"GRUINÆ."

Sub-fam. 1.—"Gruinæ proper."

Examples.—*Grus montignesia*, Bonap.; *Grus antigone*, Linn.; *Balearica pavonina*, Briss.

Sub-fam. 2.—"Psophiinæ."

Examples.—*Psophia crepitans*, Linn.; *Rhinochetus jubatus*, Verr. et Des Murs.; *Eurypyga helias*, Linn.

The genera *Grus*, *Anthropoïdes*, and *Balearica*, form a very natural group, and easy of definition; but the three genera which I have placed together as the Sub-family Psophiinæ differ in no small degree from the more familiar typical Cranes, and in a less, but considerable degree from each other. The reason appears to be this, that the *Psophia* and the *Eurypyga* in tropical America, and the Kagu (*Rhinochetus*) in Australia, each represent a nearly extinct group; and the three groups may in past times have rivalled the typical Sub-family in genera and species. As these scantly represented types bear a fundamental embryonic relation to the nobler typical species, a comparison of the structures of the embryo of the latter will correspond with and explain the feebly expressed adult condition of the former; whilst, on the other hand, we shall be able to see in the variations from what is typically Gruine in the aberrant forms, to what outlying groups the Cranes have most affinity. I am able to give (see Plate XIV, figs. 6—8, magnified one and a half diameters) the Shoulder-bones and Sternum of a recently hatched Mantchourian Crane (*Grus montignesia*): for the structure of the adult Cranes I must refer to the specimens in the Hunterian and British Museums.

The scapula (fig. 6, sc.) is long and ensiform; it is soft at its glenoid (gl.) and supra-scapular (s. sc.) regions. The coracoid (cr.) is moderately long; its head is large and round, and its epicoracoid base (e. cr.) is large and semilunar; these parts are still unossified. One very important character of the Crane's coracoid is the large development of the meso-coracoid (m. cr.); it is not so large, relatively, in the embryo as in the adult, as it receives much increment from the periosteal layers; here it is seen to be soft down to the foramen (cr. f.), but it is ossified from the main shaft, below. The clavicles (cl.) receive but little augmentation from the meso-scapular and præ-coracoid segments; their main part (cut away in fig. 6, to show the Sternum) is a slender rod in the early stage; below they have coalesced with the pointed inter-clavicle. Already this part (i. cl.) is wedged in between the halves of the sternal keel, at the angle (k.), ready for the complete coalescence of these parts, which takes place in the adult Crane. Moreover, this occupation by the inter-clavicle of the primordial sternal fissure is what we have already seen in certain Lizards where the Sternum is always flat and keelless (see Plate IX, figs. 8, 9). As the lateral parts of the Sternum chondrify before the middle (or ento-sternal), they may, as to time, be said to be primary, and the mid-portion secondary; and if these secondary parts, namely, the rostrum (r.), the lower coracoid lip defining the groove (cr. g.), the keel (k.), and the middle and intermediate xiphoid processes (m. x., i. x.), had not as yet been developed, then the Sternum would have been composed of two narrow bands, diverging from each other, both before and behind. Behind their connection with the perfect costal arches these bands approach each other, but further backwards (e. x.) they diverge very much, and this divergence is precisely that which obtains in those Reptiles (*Stellio* and *Crocodilus*, see Plate XI, figs. 2 and 8, x. st.) that have free xiphisternal horns.

At present the rostrum (r.) is a small projecting papilla, and the coracoid grooves (figs. 6—8, cr. g.) meet at an acute angle, and overlap, so that the right coracoid passes beneath the left for a small distance.

The keel (k.) occupies merely the middle third of the Sternum, a little nearer the end than the front; it is a sharp, flat crest (fig. 7, k.), and its angle is produced forwards as two distinct narrow flaps, that embrace the inter-clavicle (i. cl.). In front of the keel there is a lanceolate fossa (fig. 6, f.); this is a correlate of the upward curve of the trachea. There are seven pairs of lateral papillæ, which will be converted into costal condyles (fig. 7, c. c.); the sternal ribs (the first of these, s. r. 1., is shown in fig. 6) are still soft.

Amongst the skeletal parts of *Grus antigone* in the Hunterian Museum ('Catal.,' vol. i, pp. 246 and 247, Nos. 1319—1332), there is the Sternum of a half-grown bird; in it there may be seen a large, ovoidal scooped space, some distance below the rostrum; this invades the front of the Sternum, and is a development of the *fossa* shown in Plate XIV, fig. 6, f. In this more advanced stage the inter-clavicle only articulates with the projecting keel, and the tracheal loop turns suddenly upwards, apparently causing non-development and absorption of the bone nearly to the lower coracoid lip.

The front of the keel is scooped at this second stage, but it is thick behind the vertical fossa, and then for the rest of its extent is flat, as in other Birds. In the adults, however, the trachea has passed along, inside, to the extreme end of the keel, which bulges upwards into the thoracic cavity behind; grows into a bony box, which is continuous with the rostrum, in front; whilst at the angle complete coalescence has taken place with the interclavicular part of the furcula.

In outline the Sternum has become long-oblong, and the posterior margin has an almost transverse outline, the elegant but small notches of the embryo having become converted into gentle sinuosities.

In *Balearica* the furcula is less V-shaped than in *Grus;* it does not reach the angle of the sternal keel, which is not produced so much forwards; the Sternum is neatly oblong, a little broader in front than behind; the hinder margin is gently trilobate, and a trace of the "intermediate notch" is seen on the middle lobe, on each side; in this genus the trachea does not enter the keel, and the keel itself scarcely reaches the end of the Sternum.

In *Psophia* (see 'Catal. Hunt. Mus.,' vol. i, p. 248, No. 1343) these parts are intermediate between those of the embryo of the typical *Grus* and the adult *Balearica.*

The scapula of *Psophia* (Plate XIV, fig. 9, sc.) is considerably curved, unusually broad, and has a strong, blunt, out-turned acromion process. In *Rhinochetus* the scapula has a similar shape, but it is altogether smaller and more bent, being a very rudimentary form. In *Eurypyga* the scapula is almost the exact counterpart of that of *Psophia.* The coracoid of *Psophia* (Plate XIV, fig. 9, cr.) agrees with that of the typical Cranes; the meso-coracoid plate (m. cr.) having a unique development for a Bird, and the coracoid foramen (c. f. m.) is nearer the posterior than the front margin and the bone. In *Rhinochetus* the coracoid is long and slender, and the meso-coracoid ledge of bone becomes narrow in the middle, but never dies out; in neither of these types is there anything more than a rudiment of the epicoracoid hook. In *Eurypyga* the coracoid approaches that of the Pluvialinæ, but, nevertheless, the meso-coracoid ridge is continuous along the inner side of the bone, although narrow; the epicoracoid hook is large. The furcula of these species is very instructive; in *Psophia* and in *Eurypyga* it comes close to that of the Pteroclinæ, answering very exactly to that of a young Plover; yet in it *Psophia* is more V-shaped, and in old age the inter-clavicular bar is nearly as well developed as in the Gallinaceæ; and the thick tip of each ramus is caused, as in them, by the solid ossification of a lump of cartilage—the "meso-scapular segment." In *Eurypyga,* as in *Pterocles,* the inter-clavicle is a small tubercle, like that of an embryo Plover, and the rami of the furcula are bent backwards, and not so much thickened by the cartilaginous segment. The furcula of the Kagu (*Rhinochetus*) is intermediate between that of a Tinamou and a Rail; it is long, and U-shaped; the tips of the rami are curved backwards, and, as in those types, there is no trace of an inter-clavicle: it answers to the furcula of the Plover, before the inter-clavicle appears. The Sternum of *Psophia* is exactly intermediate between that of the embryo Crane (Plate XIV, figs. 6—8) and that of *Balearica.* The Sternum of the Kagu is arrested at an earlier stage than what is seen in the ripe embryo of the Crane; for the rostrum is absent, and the anterior margin shows the primordial notch as in *Brachypteryx* and *Apteryx* (see Plate XVII, fig. 1); its keel also is in a similar state of arrest. In *Eurypyga* the outer xiphoid notch is almost as much developed as in *Himantopus;* the rostrum is equal to what is seen in the true Ardeinæ; the keel is intermediate between that of a Plover and the *Psophia;* but, as in the latter form, it is *pneumatic* and not *oily,* as in the true Plover. A rare and unique notch appears at the end of the keel, tending to separate it from the body of the bone.[1]

[1] I have no room here for further detail as to this instructive group of *ancient types* of the Grallæ; but the osteology of the Kagu and its relations will be explained and illustrated in a paper by me, soon to appear in the 'Zoological Transactions.'

Family—"RALLINÆ."

Example.—Gallinula chloropus, Lath.

These birds, which range in size from that of a Quail to the bulk even of a Cassowary,[1] are very easily characterised; and form a neat group. They have very compressed bodies, and very feeble wings, and this peculiarity in their form and structure so modifies their Shoulder- and Breast-bones as to mask their relationships. In their skull and face they differ very little in essentials from the Cranes; and in their skeleton, generally, they intervene between these birds and the Plovers, it being more *pneumatic* than the latter, and less so than in the former. Whilst acquiring no higher cerebral development than the Ostrich tribe, they differ from them, far more than do the Plovers, in the structure of their skull, having, like the Cranes and the Bustards, the "anterior pterygoid processes" aborted. They agree with the Gallo-struthious group, with the Herons, and with the genus *Podiceps*, towards which they seem to lead—in the absence of the "lateral occipital fontanelles," so largely distributed in the Wading, Swimming, and Diving Birds. Connecting links must be looked for between the Rails and the Kagu on one hand, and between the Grebes and the Coots on the other: they have also no little affinity for the Herons. The Shoulder-girdle and Sternum of *Gallinula* is shown in Plate XV, fig. 4, magnified six diameters: the dissection was made from a half-ripe embryo. The scapula (sc.), which is only partially cloven from the coracoid, is extremely slender and long; it is moderately arcuate, and almost runs to a point in the supra-scapular region (s. sc.); about half of the scapula is invested with bone. The meso-scapula (m. sc.) is blunt and short, and it has given off a delicate bar of cartilage (m. sc. s.), and in fig. 5 it is shown as magnified forty diameters. The coracoid (cr.) is shorter and broader than in the adult; it is only half covered by the ectosteal layer; its unossified regions show the breadth of the meso-coracoid ledge (m. cr.), both above and below, and that the "foramen" pierces the cartilage, as in the Crane. In the old bird the meso-coracoid ledge is continuous, but it is sharply developed, as a crest pointed above, on the lower third of the inner margin of the bone. As in the Pluvialines, the epi-coracoid (e. cr.) is well developed, and hooked; these parts, however, do not nearly meet and overlap on the edge of the Sternum, but continue far apart, as in the weak-chested Kagu. The furcula is between a U and a V in shape, and is very slender; each ramus dilates where it meets its fellow (see fig. 6 cl.); but there is no inter-clavicle: in the old bird the line of junction is produced upwards, as in the Herons, but not to the same degree. The tips of the furcular rami are knobbed by the addition of the meso-scapular segment, but they are very little decurved—not so much so as in the Kagu. Seen laterally, the clavicles of the Gallinule are more curved than those of the Kagu, but are straighter

[1] I include the lately extinct New Zealand forms; I have already shown ('Phil. Trans.,' 1866, p. 163) that the *Dinornis casuarinus*, or *Aptornis* of Professor Owen, was a gigantic Rail, and I am fully satisfied that his new genus *Cnemiornis* (see 'Zool. Trans.,' 1866, vol. v, part 5, pp. 395—404, pls. 63—67) was nothing more or less than a giant of the Rail-tribe, and perhaps owned the well-known pick-axe-shaped head, supposed to have been useful in stubbing-up fern-roots.

than those of the *Psophia* and *Eurypyga*:—straight, slender clavicles generally go with feeble wings; but the Pigeons are notable for being exceptional in this respect.

The Sternum of the Gallinule is very elegantly formed (see Plate XV, fig. 4), the anterior part being narrowed more and more to the last sternal rib, and then the external xiphoids (e. x.) becoming gently curved out and then incurved; the middle xiphoid (m. x.) is much shorter than the outer bars, and narrows to a point. There is no room for an inner notch, and the outer is very deep and reaches nearly to the costal region; in that part there are six pairs of condyles (c. c.), the normal number for a Ralline Bird. The keel (k.) is a good distance from the anterior margin, on which there is, at present, no rostrum, and the keel itself is very slight. In the old bird there is a shallow notch between the upper coracoid lips, and a small, carinate, tongue-like rostrum; the whole Sternum becomes relatively much narrower, and the xiphoid region much longer in proportion to the costal. The costal processes of the adult are more produced and sharper; the keel has become moderately deep; the external xiphoids diverge much more behind, enlarging the notch, and they and the middle xiphoids have become somewhat dilated near the end, and do not ossify entirely. The anterior third of the keel, in the specimen before me, is partly separated from the rest by a small fenestra.

The Sternum of *Tribonyx mortieri* (Hunt. Mus., No. 1281) is in form, almost the exact counterpart of that of the embryo Gallinule; it has, however, a very small rostrum, and it has relatively a deeper keel; its furcula is strong for a Rail. The Coot (*Fulica atra*) has a broader Sternum than the Gallinule, and its external xiphoids projects so much that it is intermediate in form between that of the Land Rail and that of the Grebe (*Podiceps*); see Plate XIV, figs. 4, 5.

In the Crake (*Crex pratensis*) the Sternum agrees with that of the Gallinule in its parts, but it is much narrower, and the xiphoid notch is a very narrow slit. In *Brachypteryx australis* (Hunt. Mus., No. 1280) the Sternum has much the same relative breadth as in *Crex;* but in the latter form the external xiphoids diverge, whilst in *Brachypteryx* they cling close to the deeply emarginate middle part. Here, also, the rostrum is absent, so that this most elementary Sternum, deeply emarginate before and behind, is in all essentials, just like that of *Podiceps*. The Sternum of the *Porphyrio* agrees on the whole with the Gallinule, but it is much more pinched in the costal region, which is relatively longer; its external xiphoids are much broader and more expanded terminally, but they retain the incurved condition seen in the embryo of the Gallinule. In *Ocydromus australis* the scapulæ are shorter and more dilated at their supra-scapular end; the furcula, like that of *Brachypteryx*, is extremely slender towards the angle, and the Sternum is like what is seen in that species, save that it has a slight rostrum, a smaller emargination behind, freer external xiphoïds, and these bars have pedate cartilaginous ends; the keel, also, is more developed. If the important sternal fragments figured in Professor Owen's valuable paper on *Cnemiornis* ('Trans. Zool. Soc.,' 1866, vol. v, p. 63, figs. 5—9) belonged to the same species as the leg bones, then there have been Rails with a Sternum intermediate in carination between that of a Rhea and an Emeu.

There is still a most important group of the Grallæ to be noticed, viz. the Erodiones; these Birds have tender young like the Pelecaninæ and the Raptores; they are widely diversified in non-essentials, but in all essentials they have much in common. The true Herons (*Ardea*, &c.) come closest to the Rails; the Ibises to the Tringinæ (*Tringa*, *Totanus*, *Numenius*, &c.); whilst the Flamingoes and Spoonbills approach the Geese; with the Pelecaninæ, also, they have marked affinities. The difficulties experienced by all naturalists in the classification of this group seem to me to arise from the hiatuses caused by extinction, so that some Sub-families are represented by a single genus, or even species. I would, for the present, arrange them in the following order:—

"GRALLÆ ALTRICES" vel "ERODIONES."

A. With a long and slender tongue, as a rule; the exception, being *Cancroma*.

Sub-family—"ARDEINÆ" (PROPER).

Examples.—*Ardea*, *Botaurus*, *Nycticorax*, *Cancroma*,[1] *Erodius*, *Tigrisoma*.

B. With a small, triangular, flat tongue.

Sub-family—1. "SCOPINÆ."

Examples.—*Scopus*, *Balæniceps*.

Sub-family—2. "CICONIINÆ."

Examples.—*Ciconia*, *Leptoptilus*.

Sub-family—"IBIDINÆ."

Examples.—*Ibis*; *Threskiornis*, *Platalea*.

C. With a large, solid, fatty tongue, and horny lamellæ on the edges of the beak, as in the *Anserinæ*.

Sub-family—"PHŒNICOPTERINÆ."

Example.—*Phœnicopterus*.

Sub-family—"ARDEINÆ."

The frail, flat-bodied Herons, with their extremely long necks, are like creatures arising, if

[1] If I were writing upon the Skull, *Cancroma* should have gone into the Family Scopinæ; its Shoulder-girdle and Breast-bone, however, are typically Ardeine; as far as grouping is concerned, I am more anxious to ascertain structure, than to make a "system." Professor Huxley in his recent "Hunterian Lectures," and in a paper read at the Zoological Society this spring (April 11th, 1867, see 'Proc. Z. S.,' 1867, pp. 415—472), has shown but little mercy to "that type of doctrine into which we have been cast" by Cuvier and others. I hail the appearance of that paper as a proclamation of liberty to all who have been bound by our great, but now somewhat obsolete rulers.

such a thing were possible, between a Rail and a Cormorant. They have a long, arcuate, blunt-pointed scapula, with a short acromion process; a long, slender coracoid, with a high head, a curled meso-coracoid process, and a hooked epicoracoid angle; whilst the broad base is greatly scooped within; these bones overlap each other. The cartilaginous segment is not divided thoroughly into a meso-scapular and a præ-coracoid; but it may ossify separately above (see Plate XIV, fig. 10, m. sc. s., which shows the furcula of *Ardea purpurea*), whilst below the head of the coracoid the lower moiety forms a ledge on the shoulder of the furcular ramus. The clavicular bones (cl., i. cl.) are very Lacertian, for they form a four-rayed tract of bone: here, however, the ascending ray is principally formed by the clavicles themselves, for the inter-clavicle is small; it forms the flat head that articulates, in most species, with the flattened angle of the sternal keel. This joint is not formed in *Cancroma* nor in *Botaurus stellaris*, where the ascending bar is as feeble as in the Rails. In *Tigrisoma leucolophum* it is quite absent, and the inter-clavicle forms a small bony pimple below the junction of the clavicles, as in *Eurypyga* and *Pterocles*. In *Tigrisoma* the furcula is nearly U-shaped; the rami are much nearer together in the other Herons; the ascending process is very large and clubbed in *Ardea cinerea*, and this species has the most massive inter-clavicle.

The Sternum of the Herons is oblong, the length being twice that of the breadth; it has a narrow notch between the coracoid grooves, and a long rostrum below them. The keel is large, runs the whole length of the Sternum, is deeply concave in front, and very arcuate in its lower outline; in the more typical kinds the apex of the keel is flattened for the inter-clavicle. The coracoid grooves largely overlap, the right passing beneath the left; the costal processes are large, somewhat triangular, and diverging; behind them there are four costal condyles in the more typical kinds, and three in *Botaurus stellaris* and *Tigrisoma leucolophum*. There is one great triangular "xiphoid notch," but its inner margin is sinuous, showing a tendency to the formation of the inner notch. The Bittern and the Tiger-bittern have the "rostrum" much smaller than in *Ardea*, and the Sternum much narrower; in the former there are two pairs of notches, as in the Ibis; both small, but the inner ones much less than the outer; this Bird has the most of the Rail in its head and face. But the Tiger-bittern, which has the skull and face of a *miniature Adjutant*, has the Sternum extremely like that of a Gallinule, the single pair of notches being very deep; the whole Sternum very narrow; the outer xiphoid bars very long and sigmoid; and the "rostrum" scarcely more developed than in the Rails. In *Erodius*, *Nycticorax*, and *Cancroma* the Sternum agrees with that of *Ardea*.

Sub-family—SCOPINÆ.

I place the Umbre and Balæniceps together, notwithstanding the many things in which they disagree; for, in comparing them with their Ardeine congeners, they evidently have no known relatives so near akin to them as they are to each other.[1]

[1] See Dr. J. Reinhardt's paper on the "Affinities of the Balæniceps" in the 'Transactions of the Royal Danish Scientific Society,' for April, 1861, pp. 135—154, and translated for the April Number of the 'Ibis,' 1862; see also my paper on this bird, 'Trans. Zool. Soc.,' 1861, vol. iv, pp. 337—341, and pls. 66, 67.

The scapula, as in the Storks, is stouter and broader than in the Herons, so also is the coracoid; there is a distinct epicoracoid hook, and, especially in the Balæniceps, a well-developed meso-coracoidal curled plate (see 'Trans. Zool. Soc.,' 1861, pl. 67, fig. 1 cor.). In the large form the base of the coracoid extends far backwards, and these bones *almost meet* at much less than a right angle, but in *Scopus* at an obtuse angle. In one important point they agree as to the furcula, namely, they have the "præ-coracoid segment" very massive, as in the Pelecaninæ (*op. cit.*, pls. 66, 67, f. c.); this part forms a flat-topped mass, which fits by a synovial joint to the under-surface of the head of the coracoid. In *Scopus*, however, the rest of the furcula is Pluvialine, for it is a broad U-shaped bone, ending far from the Sternum, and having a semilunar inter-clavicle behind. In *Balæniceps*, however, the rami are straighter, and the inter-clavicle, the clavicles, and the angle of the sternal keel, form one solid bony mass, even in a young (yearling) bird; this also is a Pelecanine character. The Sternum is short and broad in both, as in the Pelican, the Cormorant, and the Stork; but it agrees with the latter, its nearest congener, in having the keel complete to the end (*op. cit.*, pl. 67). The costal processes are squarish and well-developed; there are five pairs of costal condyles in *Balæniceps*, and five (in my specimen) on the right side, in Scopus: on the left side I find six. *Scopus* agrees with *Threskiornis* in having a small, pointed, keeled rostrum, as in the Rallinæ; but in *Balæniceps* the front edge of the keel is flush with the rostrum: the keel is deepest in *Scopus*. In this latter Bird there is a large semi-oval notch in the left xiphoid region, and the outer bar is short and broad, as in the Stork; on the right side this bar is notched—instead of the middle plate, as in *Platalea*, but not to the same extent. In *Balæniceps* there are two notches on each side, the outer the largest (*op. cit.*, pl. 67, fig. 1, hy.,—*hyposternum*, as it is there called); and this bar projects as in the Cormorant, but to a greater extent, far beyond the rest; the intermediate bars do not reach so far as the middle process. The Adjutant and the Balæniceps agree in having their coracoids apart; but there are wide differences in other respects.

Sub-family—" Ciconiinæ."

The scapula and coracoids are very stout, and the latter of great length in *Ciconia* and *Leptoptilus*; in both they meet at an acute angle, and whilst they do not reach each other in the latter, they overlap in the former to some extent, but not to the same degree as in the Herons. The furcula is most U-shaped in *Ciconia*; but in both it has very little additional substance derived from the cartilaginous segments; the rami, therefore, pass as flat bones inside the coracoids; in both they articulate, by a flat joint on the short inter-clavicle, with the flattened angle of the sternal keel. The rostrum of the Sternum is free in both; and the front of the large *perfect* keel is concave; in *Leptoptilus* there is one large notch and the rudiment, beside it, of another: in *Ciconia* both sides of the large single notch are sinuous.

Sub-family—" Ibidinæ."

Threskiornis and *Platalea* come very close together in most respects; they have less of the Pelecanine type in them and more of the Plover. The coracoids overlap—the left uppermost; but they are shorter in proportion to the scapulæ. The furcula has but little trace of the præ-coracoid; it is broadly U-shaped and Anserine in both; and there is a small pimple-shaped inter-clavicle in *Threskiornis*, but none in *Platalea*. The Sternum is thoroughly Pluvialine in both; but whilst the outer notch is largest in *Threskiornis*, the inner is the largest in the Spoonbill. The latter agrees with *Ciconia* and *Leptoptilus* in having five pairs of sternal ribs, whilst the Ibis has six; this bird has a small "rostrum," which is aborted in *Platalea*.

Sub-family—"Phœnicopterinæ."

With the Flamingo, evidently *Anserine* in many respects, the Ibis has the greatest right of relationship. The scapula of the former, unlike that of the Ibis, is very long and narrow, more so than in the Goose; the coracoids are shorter, broader, and more Goose-like; and they have large meso-coracoid processes: they overlap, as in the Ibis. The furcula is very much like a broad U, as in the Spoonbill; but it has, like the Umbre, a well-developed Pluvialine interclavicle; it has scarcely any "præ-coracoidean" enlargement.

The Sternum of the Flamingo is more elongate by far than in the other Ibidine forms; it has the thick "rostrum," and the long, oval, single pair of notches of a Goose; the ends of the three xiphoid processes, as in the Ibis, do not ossify, even in old age. These cartilaginous parts are pedate, more so than in the Ibis, less so than in the Goose; and the notch on each side is so clean-cut that it shows, as in the Goose, no disposition to add another cleft. As in the Goose, the outer bars of the Sternum of the Flamingo project further backwards than the middle piece; whereas in the Ibis they are the shortest, thus showing their Pluvialine nature.

Family—"RAPTORES."

Sub-family—"Accipitrinæ."

Example.—*Nisus communis*, Cuv.

Sub-family—"Striginæ."

Example.—*Ulula aluco*, Linn.

Sub-family—"Serpentariinæ."

Example.—*Dicholophus cristatus*, Linn.

These Birds, as at present known, form a very natural assemblage, and their relationships to other groups are in no wise evident, especially if the typical forms are considered; the most aberrant form, the Cariama, stands far off from any known Bird, although its isomorphism with the Grallæ is so great as to have misled some of the greatest ornithologists.[1]

I shall consider the Raptores as forming four sub-families, namely, the Accipitrinæ, Striginæ, Vulturinæ,[2] and Serpentariinæ: this last group contains two genera, namely, *Secretarius* and *Dicholophus*, each of which ought to stand at the head of a distinct Sub-family. I do not quite despair of finding some relatives of the Cariama amongst the South American Birds; they would, however, have to be sought in the direction of the Cracinæ, rather than near the Storks and Cranes.

The Shoulder-girdle and Sternum of the half-fledged Sparrow Hawk (*Nisus communis*) are shown in Plate XV, figs. 7—11, figs. 7 and 8 being of the natural size, fig. 10 magnified two, fig. 9 seven, and fig. 11 ten diameters. The scapula (sc.) is ensiform, the supra-scapular end (s. sc.) is still soft; and so, also, is the base; the acromion (m. sc.) is blunt.

The coracoid (cr.) has its head and epicoracoid region still unossified; this part (e. cr.) is considerably produced backwards; the meso-coracoid spur is moderately developed; and from the head of the bone there has been segmented a thick, similunar, præ-coracoid (p. cr.). The clavicle (cl.) is very broad and flat at its shoulder; it is strongly curved backwards, and even upwards; this is intensified in the adult; the inter-clavicle (i. cl.) is small even in the adult.

All the Raptores, from *Falco* to *Dicholophus*, show the Pelecanine character of a large præ-coracoid segment; but only in one kind, namely, the *Serpentarius*, does the inter-clavicle articulate by a flat joint with the angle of the sternal keel, as in the Pelecaninæ. The præ-coracoid, however, does not ossify by itself in the Raptores, but receives its osseous matter from the clavicle (see fig. 11). It first undergoes vertical cleavage into an anterior and a posterior part, the former continuing some time as hyaline cartilage (c.), and the latter becoming converted into fibro-cartilage (f. c.); this forms the gristly pad which abuts against the flattened lower surface of the head of the coracoid. The osseous matter (o.) of the clavicle (cl.) then creeps into the anterior lamina, obliterating it, just as the meso-scapular cartilage was obliterated before hatching; lastly, the bony matter affects much of the fibro-cartilaginous pad itself; a synovial cavity meanwhile being formed between this præ-coracoidean shoulder of the furcular ramus and the head of the coracoid: none of these changes could have been guessed at by observation of the adult bones. The Sternum of *Nisus communis* (figs. 7 and 8) may be taken as typical; it is short-oblong and broadest behind; it has a considerable keel (k.), which is sharply differentiated from the pointed rostrum (r.); behind, it is notched or fenestrate (both in the same individual, see fig. 8) into three xiphoid processes. The costal processes (c. p.) are short; the coracoid grooves (cr. g.) overlap; the right passing below the left, as is normal in Birds; and there are seven condyles for sternal ribs, the last becoming aborted. The osseous matter (fig. 7) has grown from the two "pleurostea" (pl. o.) up to the condyles, and the "lophosteon" (lo.) has lost its distinctness; there is some disposition to form a fifth pair of centres, but they are not very distinct. Fig. 10 shows how the bony matter creeps into the body of the Sternum; and fig. 9 shows that the "lophosteon" is an *endosteal* deposit originally, as in the Reptiles—the bony matter creeping in two tracts into the hyaline cartilage. In the Owls, the

[1] For instance, G. St. Hilaire, Burmeister, Martin, Reinhardt, and Nitzsch (see his 'Pterylography,' translated by Dr. Sclater, Ray Soc., 1867, pp. 122, 123). In a recent conversation with M. Alphonse Milne-Edwards I was very pleased to find that no place amongst the Grallæ had been found by him for this bird.

[2] The Cathartinæ deserve to be separated from the Vultures, and the Falcons from the Hawks and Eagles.

parts of the Shoulder-girdle are slenderer than in the Falconinæ, and the furcula, especially, is feebler and less indebted to the præ-coracoid segment; the inter-clavicle is aborted. In *Athene noctua* the clavicles do not meet, but terminate in sharp points below. In *Serpentarius* the scapula is narrow, and much straighter than in the other Raptores, except *Elanus*—an Egyptian Kite; yet the coracoids of the Secretary are very stout, as in the Vultures, but as in the Cariama, they do not meet below; its furcula has the rami less bent; and there is a large inter-clavicle, which first articulates and then coalesces with the apex of the sternal keel. In the Cariama the scapula (Pl. XIV, fig. 11, sc.) is the precise counterpart of that of a Falcon or a Vulture (*e. g. Percnopterus*), but the coracoid (cr.) is like that of an Owl; the meso-coracoid ridge on the inner side being sharp and free; and the epicoracoid angle (e. cr.) being scooped, which scooping is continued far up the outer edge of the bone; the meso-coracoid process is also very large. I am certain that no anatomist could tell either the furcula or the coracoid of this Bird from that of an Owl, supposing them to be presented to him loose, and not labelled. The præ-coracoid ledge of the furcular ramus (p. cr.) is, as in the Owls, rather flat; the rami (cl.) are very flat, very narrow in their lower third, meet at an acute angle to form a V-shaped bone, and have scarcely a trace of an inter-clavicle; they are connected to the angle of the keel by ligament, at the same relative distance from and height above the angle of the keel.[1]

There is one most unique character in the Shoulder-girdle of the Cariama; for although the clavicle is close at hand it has not supplied the meso-scapular segment (m. sc. s.) with bone, as usual, but this part is a little, distinct bone, as in certain mammals.

Most of the Eagles and even Vultures agree in the form of their Sternum with *Nisus communis* (Pl. XV, figs. 7 and 8); but the rostrum is generally smaller, and in the larger types the keel is less deep relatively, being very small in proportion to the enormous pectoral muscles: the keel retreats in all, but most in the large Vultures. The xiphoid region is generally like that of *Nisus;* but, as a rule, the spaces are fenestræ in the adult: they are very large in *Gyps fulvus;* in *Polyborus caracara* and *Cathartes californiensis* the notches do not close; in *Aquila Pennantii, Cathartes aura,* and *Elanus melanopterus,* there is an outer fenestra and an inner notch. In *Sarcoramphus papa* and the Owls (Plate XIV, figs. 13, 14), there are five bars and four notches behind; the notches are deepest, and the bars narrowest in *Athene;* and the opposite to this is seen in *Strix flammea.* In *Aquila chrysaëtos* and in *Haliætus* the fenestræ are apt to close up. In the Vulturinæ, Falconinæ, and Striginæ, the xiphoid region is almost transverse (see Plate XIV, figs. 13, and Plate XV, fig. 8); but in *Gyps fulvus* the middle xiphoid runs backwards as a triangular tongue of bone. This character is intensified in *Secretarius,* which has also two very minute xiphoid notches. In the Cariama the Sternum is still more elongated and narrowed (Plate XIV, fig. 11), and the keel, which is very large in *Serpentarius,* is twice the relative size of that of *Gyps.* This length, and the depth of the notch behind, gives a Gallinaceous character to it; but in that group it is the inner notch which is large; whereas in the Cariama it is the outer; for on holding up the bone to the light the inner fenestræ can be seen (fig. 1, i. x. f.) although filled in by periosteal layers. The middle xiphoid (fig. 12, m. x.) becomes very narrow where the keel is dying out,

[1] I have notes and sketches of the digestive organs of the Cariama; they answer not to those of the Hawk or the Vulture, but to those of the Owl; the tongue corresponds to that the Hawk and Owl; and so do the organs of voice: there is a pair of fan-shaped inferior laryngeal muscles, which, some at least, of the Vultures do not possess. The skull and face are of those of *an enfeebled* Falcon; so that this is a very generalised bird, and probably of very ancient descent.

and at the narrowest part the ossification ceases suddenly; there is then an elegant heart-shaped leaf of hyaline cartilage, in which *a unique ossicle* appears—the "urosteon" (u. o.); if this part had been quite segmented off, we should have had a *free* "metasternum." All these are characters belonging to the Cariama, and showing its generalised nature. As a rule the coracoid grooves overlap in the Raptores; they do not quite meet in *Athene;* are still further apart in *Strix flammea;* and are most widely separated in the Cariama, in *Serpentarius,* and in *Falco peregrinus:* the skull of this latter bird, the very noblest of the entire Family, is the one which throws most light upon that of the Cariama. The "rostrum" is moderately developed in all the *diurnal* kinds, but is very small in the Owls, especially in *Strix flammea;* in the Cariama (Plate XIV, fig. 11 r.) it is less than in the Secretary Bird, and is intermediate between that of the Hooping-owl (fig. 14, r.), and that of the Screech Owl (*Strix flammea*). The costal condyles are five or six in number in the Raptores generally, there are six in *Elanus, Ulula,* and *Percnopterus; Gyps fulvus* has four, and these are very large; and the Cariama has four very large costal condyles for four large sternal ribs, on each side; in front of these there is a very small sternal rib, attached by ligaments (fig. 11). As in *Falco æsalon* and *F. peregrinus,* the Cariama has a free abdominal rib on each side (fig. 11, a. r.); it may be seen on the left side in *Ulula aluco.* The sternal ribs of the Secretary and the Cariama are equally stout; the former has a sixth pair reaching the Sternum.

Sub-ordo—"PICARIÆ."[1]

This provisional Group has the Woodpecker (*Picus*) for its centre, this being a medium type; the ultra type, or that which has the characters of this Sub-order in the highest degree, is the Parrot (*Psittacus*); here this group culminates: the most aberrant forms are the Goat-suckers (*Caprimuglus*), and Humming-birds (*Trochilus*).

The families which I have studied most are the Psittacinæ, Picinæ, Ramphastinæ, Musophaginæ, Cuculinæ, Bucerinæ, Alcedinæ, Meropinæ, Coraciinæ, Galbulinæ, Caprimulginæ, Cypselinæ, and Trochilinæ.

Family—"PSITTACINÆ."

Examples.—*Psittacus erythacus,* Linn.; *Agapornis pullaria,* Linn.; *Strigops habroptilus,* G. R. Gray.

The Shoulder-girdle of the Parrot-tribe is most perfect in the larger species; the smaller kinds often have the clavicles absent. This is shown in Plate XIV, fig. 15, which represents the

[1] I learnt this term from Dr. Sclater, but my use of it will be much wider than his; I want it to take in all those arboreal Birds which are neither *Passerine* on one hand, nor *Gallinaceous* (e. g. the Pigeons) on the other. Many of Cuvier's Passerinæ must be arranged round *Picus,* viz. his Tenuirostres, and part of his Fissirostres, and not in the neighbourhood of the true Passerinæ.

Shoulder- and Breast-bones of *Agapornis pullaria* (one and a half diameter). The scapula (sc.) is ensiform, gently curved, enlarged at its upper third, and then very pointed. The acromion is short and square; it articulates with the upper part of the meso-scapular segment inside the head of the coracoid. This latter bone (cr.) is an elegant, long, phalangiform ray; it has the head enlarged, the meso-coracoid process well developed, and the epicoracoid spur moderate. The meso-scapular segment (m. sc. s.) is here a separate, hatchet-shaped bone, with no clavicle attached; it lies on the inside of the head of the coracoid, and the meso-scapular spur and the meso-coracoid spur curl round to articulate with it. This bone is a rudiment of the *compound* "furcula;" but it is not part of the clavicle, which here, as in *Melopsittacus undulatus, Psephotis multicolor*, &c., is entirely absent. In *Psephotis multicolor* the meso-scapular segment coalesces with the head of the coracoid. In the larger (and in some small) kinds of Parrots, for instance, *Manodes discolor*, the "furcula" is developed (see Plate XIV, figs. 16, 17, which shows that of *Psittacus erythacus*), the clavicles becoming anchylosed to the meso-scapular segment in old age, but having no inter-clavicle at the angle. The furcula is V-shaped, and its rami are flat and rather feeble. I have already spoken of the furcula of the Psittacinæ[1] (see 'Proc. Zool. Soc.' (1865, p. 238) in a description of the osteology of *Microglossa alecto*. The Sternum of the Parrot-tribe is very characteristic, yet it is but slightly modified from that which is seen in many of the Picariæ, the more typical forms all possessing a Breast-bone very different from that of the Passerinæ. The general outline is oblong, the length being more than twice the breadth; the upper surface is deep, especially in front; the more shallow, hinder part is expanded (see Plate XIV, fig. 15) and rounded. As a rule, there is only one fenestra—a notch in some cases—on each side. This is very apt to fill in, especially on one side. There are six pairs of condyles for sternal ribs, surmounted in part by a somewhat hooked costal process. This is not curved backwards in *Agapornis* (see Plate XIV, fig. 15). The coracoid grooves are quite distinct, but the space between them is small; above this space the upper lip is often slightly notched; below, the "rostrum" (r.) stands like the figure-head of a ship; it is thick, grooved in front, slightly notched above; and below only a shallow scooping separates it from the front of the keel. This latter part often projects in front of the rostrum below, and this front margin forms a right angle with the base of the body of the Sternum; altogether, the keel is very large in proportion to the wing-bones, and it runs to the end of the Sternum (see Plate XIV, fig. 15). In the Owl-billed Parrot of New Zealand (*Strigops habroptilus*, Plate XVII, fig. 15) the Sternum is very aberrant; the coracoid grooves are small and wide apart; are separated by a shallow notch; and the keel is very small—both short and low. The body of the Sternum is very shallow; a small double "fenestra" is seen on the left side, and two on the right side; this is quite aberrant for a Parrot. The middle xiphoid region is produced backwards; this also is abnormal. In some of the medium-sized Red-and-Green Parrots the middle xiphoid is notched at the mid-line.

[1] That little paper was written before I had thoroughly mastered the development of the Shoulder- and Breast-bones. I was wrong in saying (p. 238) that the "ento-sternal structures really belong to the shoulder-girdle," they are merely correlated, and *belong* to the costal arches. Also, I confused together the "meso-scapular," and the præ-coracoid segments of cartilage; moreover, I have since discovered that the "acromial" (meso-scapular) bone does exist in *Psephotis*; but that it coalesces with the coracoid.

Family—" RAMPHASTINÆ."

Example.—Ramphastos toco, Gmel.

The Shoulder-girdle and Sternum of *Ramphostos toco* are shown in Plate XIV, figs. 18—20. The figures are of the natural size. The scapula (sc.) is broad, curved, and strong; the coracoid (cr.) is very long and slender; its head is inordinately large, and the meso-coracoid process is very small; the epicoracoid process (e. cr.) is square and lies low; the clavicles (cl.) are moderately strong, *ƒ*-shaped, are not united below, and they are very much enlarged at the top by the meso-scapular (m. sc. s.) and præ-coracoid (p. cr.) segments; fig. 20 shows the transverse extent of this endoskeletal addition to the clavicle, and its relation to the scapula, with its short, blunt acromion (acr.); and also to the head of the coracoid. The Sternum is very elegant, and much modified from that of the Parrot; yet it is of the same essential type. It is very much shorter; has very long projecting costal processes (c. p.); a short costal region with only four condyles (c. c.): behind the fourth the Sternum becomes narrowest, and then the outer xiphoid processes expand, rising and diverging at once. There are four deep notches, the outer the deepest; the long xiphoid processes—the outer and intermediate, expand at the end, and continue soft at the broadest part; the intermediate bars are the largest, then the middle emarginate plate; whilst the outer bars, although longest by reason of the size of the notch differentiating them, end in front of the others. The coracoid grooves are some distance apart; the upper lips are separated by a semilunar notch, and the lower by the "rostrum." The rounded apex of the Sternum projects in front of the rostrum, from which it is separated by a very slight notch. The keel itself is much smaller than that of the Parrots; the front of the rostrum is grooved as in them.

Family—" PICINÆ."

Example.—Picus viridis, Linn.

In the Picinæ, for instance, *Picus viridis*, the Shoulder-girdle differs from that of the Toucan in the crozier-shaped scapula (Plate XIV, fig. 21, sc.), and in the junction of the clavicles (cl.) to form a "furcula;" without, however, an inter-clavicle; the epicoracoid process, also, is more pointed. The Sternum differs in the small size of the outer notch, which is less than the inner, and in having five costal condyles. The last sternal rib has an abdominal rib *connate* with it.

The scapula of the Wryneck (*Yunx torquilla*) is ensiform, as in other Birds; its furcula, coracoid, and Sternum agree with those of the Green Woodpecker.

Family—" MUSOPHAGINÆ."

Example.—Corythaix Buffoni, Vieill.

In the Touraco (*Corythaix Buffoni*) we have some new characters, for the Birds forming this group are not typically zygodactyle. The scapula is more elongated, and narrower; and the coracoid is not so slender as in the Toucan and Woodpecker; and both the meso-coracoid and epicoracoid regions are much more expanded: the former has coalesced with the head of the bone, forming a perfect canal for the tendon of the middle pectoral muscle, as in some of the Syndactyli. The coracoids overlap, the left passing under the right, as in *Ardea*, &c., a very rare thing for an arboreal Bird. The clavicles do not unite below, and the shoulder of each bone is enlarged below the head of the coracoid, by a thick præ-coracoid wedge, as in the Raptores. The Sternum is small, and almost square; the upper lips of the coracoid grooves are separated by a crescentic notch, as in *Picus* and *Ramphastos*, but the grooves themselves overlap. The rostrum is large, subquadrate, and separated from the angle of the keel by a deep notch: this part ends behind the rostrum considerably. The keel is very shallow, but reaches to the end of the bone; the costal processes are much shorter than in *Picus;* but there are, as in that type, five costal condyles. The outer and intermediate xiphoid bars are much narrower; the outer notch is twice the size of the inner, and all the five processes reach to nearly the same transverse line, the middle reaching a little the farthest, and the outer one ending soonest. In many respects the Musophaginæ are intermediate between the Zygodactyli and the Syndactyli.

Family—" CUCULINÆ."

Example.—Cuculus canorus, Linn.

The Cuckoos, also, are an inosculating group, but their affinities lie in the direction of the Caprimulginæ, as well as towards the Syndactyles. Perhaps the two most distinct types of the Cuculinæ are the common kind (*Cuculus canorus*) and *Leptosoma* (for an account of this latter Bird see Dr. Sclater's paper in the 'Proc. Zool. Soc.,' 1865, pp. 682—689). The typical Cuckoo has no little affinity for the typical Goatsucker (*Caprimulgus*), whilst *Leptosoma* is evidently allied both to the Plantain-eaters and to the Rollers (*Coracias, Eurystomus*). In *Cuculus canorus* the scapula is long, ensiform, gently curved, and very sharply pointed: it has a blunt acromion process. The coracoid is slender in its shaft, but the head is large and hooked, and the meso-coracoid bar is a very large, slightly curved bar, running out at a right angle to the shaft: the epicoracoid region is wide, and the ascending hook is very sharp. The furcula has its rami only gently divergent, so that it is almost V-shaped; its tips are but little enlarged by the cartilaginous segments, and it has a considerable inter-clavicle, lying in the same descending direction as the clavicles, and of an oval shape: the clavicles being long, the angle of the furcula is directly strapped to the top of the projecting angle of the sternal keel. The Sternum of *Cuculus* is short, very broad, especially behind; deep, bulging, highly cellular, and three-lobed behind. In old specimens I have seen the left "notch" converted into a "fenestra." The notches are oval, moderate in size, and the outer xiphoid bar is very broad and pedate: the middle process is very round and emarginate, and the whole outline of the end of the Sternum is nearly semicircular, the pedate extremities of the outer processes end far forwards, are very oblique, and this obliquity answers to that of the two lobes of the middle plate. The costal processes are high and square; there are four pairs of condyles, which lie very close together; there is a well-defined, narrow, projecting "rostrum," both above and below the coracoid grooves, as in the

Pigeons : the grooves themselves do not quite meet. The keel is very large, and complete to the end; it has a deeply concave front margin, for the angle sends a considerable hooked process forwards, to articulate with the furcula. In *Leptosoma discolor* (*op. cit.*, p. 687, figs. 6 and 7) the scapula is ensiform, with a very long sharp point, as in *Cuculus;* but the coracoid is very different, for the meso-coracoid plate runs down the inner edge of the shaft, as in *Corythaix,* and to a less degree than in *Coracias.* The furcula also agrees with both of those Birds rather than with the true Cuckoo; as in *Coracias* it is U-shaped, and the inter-clavicle is scarcely distinguishable; from *Corythaix* it differs in the rami being confluent, but agrees closely with that type in the thickened shoulder formed by the "pre-coracoid segment." This is seen in a less degree in *Coracias* and *Cuculus.* The Sternum is intermediate in form between that of *Cuculus* and *Corythaix,* being wider behind than in the latter, and narrower than in the former. Here the outer xiphoid bar has a small triangular notch converting it into two diverging bars, and the inner process is narrow. The costal processes are not squared, as in *Cuculus,* but rounded, as in *Corythaix* and *Coracias;* the rostrum is *inferior,* similar to that of Coracias, but smaller, and the keel, as large as that of the Cuckoo, has a more convex front margin, and a much less projecting angle, to which the furcula is attached by a much longer ligament.

Family—" BUCERINÆ."

Examples.—Buceros albirostris, Shaw; *B. ruficollis,* Vieill.

My skeletons of Hornbills (the gift of Dr. Sclater) are those of *Buceros albirostris* and *B. ruficollis.* The scapula is ensiform and very straight, especially in *B. albirostris,* and the acromion is thick and square-ended; the coracoid is stouter than in *Ramphastos,* and its meso-coracoid process is well developed, but free, and not decurrent: the epicoracoid region is expanded and slightly hooked. The furcula forms a very wide U, but the halves are not united in *B. albirostris;* they become very slender below, but above they are very thickly clubbed and cellular; this is due to the large size of the "meso-scapular segment," for the præ-coracoid segment is but little developed. The Sternum agrees with that of the Cuckoo (*Cuculus*) in the single pair of rather small notches, in the bilobate middle xiphoid plate, and in the degree in which the xiphoid region expands laterally. But in these two species the outer xiphoids project beyond the middle part, instead of being shorter; they are shorter, however, in *B. violaceus* (Hunterian Mus., Nos. 1486 and 1487): in all the xiphoid ends are permanently soft. The rather shallow keel projects forwards as in *Picus, Psittacus,* and *Ramphastos;* but it forms a more acute angle. The costal processes, are obliquely quadrangular, and there are four pairs of condyles in *B. ruficollis,* but only three in *B. albirostris,* a state of things to be seen also in *Tinamus robustus, Botaurus stellaris,* and *Tigrisoma leucolophum;* but it is rare in the Bird-class. The rostrum is more differentiated from the front of the keel than in the higher Pici; it is *inferior* in *B. ruficollis,* and it has a rudimentary superior rostral process, as in *Cuculus;* but it ascends between the coracoid grooves (very distinct in both), in *B. albirostris.* In the latter species we have a very beautiful morphological character, namely, a "fenestra," tending to cleave the "rostrum" off from the rest of the ento-sternum; a character better developed in *Upupa* (see Plate XIII, fig. 15), and very constant in most of the Gallinæ.

Family—"ALCEDINÆ."

Examples.—Alcedo ispida, Linn.; *Dacelo gigantea*, Lath.

In *Alcedo ispida* the scapula is ensiform, sharp-pointed, and much curved outwards; the acromion is very clearly defined and strongly bifurcate; the coracoid is rather slender in the shaft; the meso-coracoid is decurrent, confluent with the head of the bone, thus forming a tendon-bridge, and it reappears below, widening the bone towards the base; there is a rather wide laminar outgrowth behind the base, but no epicoracoid hook. There is a large ear-shaped ossified cartilage—the "præ-coracoid," confluent with the front of the clavicle, above; this and the bifurcate acromion are Passerine characters; the furcula is V-shaped, and the inter-clavicle is the merest rudiment.

The Sternum is short-oblong; it has high, triangular "costal processes," four pairs of condyles, and five pedate xiphoid processes, the middle process being bilobate. The outer xiphoid notches are one third larger than the inner, the processes tied together by ligament, form the arc of a large circle behind. The coracoid grooves nearly meet; the rostrum is *inferior* and projects very much, but is separated from the still more projecting keel by a very shallow notch; the keel itself is not deep. In *Dacelo gigantea* we have a similar state of things; but the præ-coracoid spur of the furcula is slender, and there is no inter-clavicle on the rounded angle of the more U-shaped bone. The keel is separated more abruptly from the "rostrum," but it is more obtuse at the angle, and thus comes nearer that of the Toucan and Woodpecker.

Family—"GALBULINÆ."

Example.—Galbula —— *?*

Plate XIV, figs. 22, 23, show the Sternum, from below, of a straight-billed Jacamar (*Galbula*), magnified two diameters. The rostrum (r.) is sharp and projecting, and the crescentic outline of the front of the ento-sternum is all the separation there is between it and the deepish keel. The costal processes (c. p.) are sharp, and rather erect; but the most instrutcive part of this Sternum is the extreme depth of the narrow, angular notches, which almost divide the bone into five parallel bars. The outer notch is deepest, and the outer bar is pedate; the inner (middle) xiphoid is keeled to the end, and sharpens posteriorly, so as to be like the upper half of a lanceolate leaf.

Family—"MEROPINÆ."

Example.—Upupa epops, Linn.

The coracoid and Sternum of a fledgling Hoopoe (*Upupa epops*) are shown in Plate XIII, figs. 15, 16, magnified two diameters. The scapula (not figured) is straighter than in *Alcedo;* the coracoid (fig. 15, cr.) agrees with *Corythaix* and *Alcedo* in having a perfect tendon-bridge formed by coalescence of the meso-coracoid (m. cr.) with the head of the bone. The epicoracoid (e. cr.) is very large, totally unlike that of *Alcedo*, and converts the coracoid into a hatchet-shaped bone. The furcula is U-shaped, has no inter-clavicle, and is only moderately thickened above by the cartilaginous segments. The Sternum (fig. 16) is very instructive; its length is twice as great as its breadth; it has only one pair of large xiphoid notches, as in *Buceros*, *Cuculus*, and *Caprimulgus;* its coracoid grooves (cr. g.) are quite distinct, and its rostrum (r.) is well notched off from the rounded angle of the large sternal keel. There are four costal condyles (c. c.) on each side, and in front of these there is an almost erect, rounded costal process (c. p.); but the peculiar character of the Sternum is this, namely, that almost half of it is in front of these costal processes. The very large rostrum (r.) is bilobate (*superior* and *inferior*), and an arrested transverse cleft, as in *Buceros albirostris*, but larger, partly cuts this process off from the body of the ento-sternum.

Family—" CORACIINÆ."

Example.—Coracias garrula, Linn.

In the Roller (*Coracias garrula*) the scapulæ are acute and ensiform; the coracoids have a large head; a decurrent meso-coracoid plate; and a sharp, outstanding epicoracoid spur. The furcula is U-shaped, as in *Leptosoma;* but it shows a more distinct rudiment of the inter-clavicle; above, the rami are thickened as in that type, and in *Corythaix*, having a clubbed end, enlarged by the meso-scapular segment, and a thickened shoulder formed by the præ-coracoid segment. The Sternum has the general outline of that of *Cuculus canorus;* but there are four notches, as in *Alcedo*, and the mesial plate is acuminate; the intermediate bar, like the inner notch, is the smallest; and both the pairs of bars are pedate: the general outline of all the five processes is lunate, much more so than in *Alcedo*. The keel is much like that of *Leptosoma*, having a more curved lower outline, and a fuller development than in *Alcedo;* but the rostrum, which is *inferior*, is as well-grown as its counterpart in *Cuculus*. The costal processes are rounded, more so than in *Alcedo*.

Family—" CAPRIMULGINÆ."

Examples.—Caprimulgus, Podargus, Ægotheles, Nyctibius.

In the typical Goatsucker (*Caprimulgus*, for instance), the scapula is ensiform, becoming broad, then out-turned, and then pointed at its end; the acromion is round and blunt. The coracoid is of moderate length (see the figure of the Shoulder- and Breast-bones of *C. stictomus* in Dr. Sclater's paper on this Family in the 'Proc. Zool. Soc.' for 1866, p. 120, fig. 6); it has a thick head, a feeble meso-coracoid process, and a large, hooked epicoracoid process. The furcula (see also *op. cit.*, fig. 6) is rather strong, U-shaped, has a flat oval inter-clavicle, a very distinct præ-coracoidal shoulder to each ramus, and a clubbed top to each formed by an equally distinct meso-scapular segment. The Sternum (*op. cit.*, fig. 6) is short and broad, becoming very wide towards the end; it has two large semi-oval notches, a pair of broad, oblique, external xiphoids, and a sub-triangular, square-ended middle plate. The costal processes are high, sharp, and recurved; there are four pairs of condyles. There is no rostrum, but the ento-sternum retains a shallow (primordial) notch, both above and below the distinct coracoid grooves. The keel is very deep, very arcuate in its lower outline, and elegantly concave in its front margin; the angle is less produced than in *Cuculus canorus*, and the inter-clavicle is attached to it by a larger ligament.

In *Nyctibius jamaicensis* (*op. cit.*, fig. 7) the coracoids are relatively longer; the furcular rami are much more pointed and curved at their tips; the præ-coracoid enlargement is indistinct; and there is no inter-clavicle. The Sternum is nearly square, the outer xiphoids bulging but little; there are four rather shallow notches, and the intermediate bars are nearly as large as the outer, the middle process equalling the two together. *Podargus plumiferus* (*op. cit.*, fig. 8) agrees morphologically with *Nyctibius*, but the Sternum is longer; its increased length being due to the large, sub-arcuate outer xiphoid bars, which reach some distance behind the middle plate, and are obliquely pedate. The intermediate bars are very small, and are differentiated from the truncated wedge-like middle plate by a small notch; they do not reach so far backwards as the middle part.

In *Podargus humeralis* (Hunt. Mus., No. 1528) the furcula is narrower, and the meso-coracoid processes are very much curled, the sternal notches are deeper, and the outer and intermediate processes are longer and narrower, whilst the middle plate is rather oblong than wedge-shaped—much wider than that of *P. plumiferus*.

In Professor Owen's valuable paper on the Dodo ('Trans. Zool. Soc.,' 1867, pl. 24, fig. 4) there is the lower view of a Sternum, said to be that of *Podargus humeralis*. This would appear to be rather a young one, or not belonging to the true *P. humeralis;* or if it belong to that species, it is a very curious individual variety. The whole xiphoid region is much feebler than in the specimen in the Hunterian Museum; the outer processes are incurved instead of spreading outwards; the right inner notch is absent; and the middle plate is wedge-shaped, narrower than in *P. plumiferus*, and very unlike that in the specimen of *P. humeralis* above referred to. In *Ægotheles cristatus* (Hunt. Mus., Nos. 1526, 1527) the Shoulder- and Breast-bones are feebler than in *Caprimulgus*, the coracoids are shorter, the furcula feebler, but having the same præ-coracoid shoulder and inter-clavicular plate. The Sternum is much narrower in front, but wider behind, and in the old bird there are four very large angular "fenestræ," the inner being the largest. These were once "notches" (see 'Ost. Catal.,' Hunt. Mus., vol. i, p. 291, No. 1527), for in the younger specimen two of these spaces are open. In the older bird all the five bars are bound together by periosteal growths, so as to form an arcuate and sinuous posterior margin with projecting and rounded angles.

Family—"CYPSELINÆ."

Example.—*Cypselus apus*, Linn.

The Swifts have their whole osseous structure correlated to the most perfect organs of flight in the whole Class; they form a connecting link between the Caprimulginæ, the Hirundinæ, and the Trochilinæ, but are much nearer akin to the first two Families. I am fortunate (with my limited space) in being able to refer to a very valuable paper on this Family by Dr. Sclater

('Zool. Proc.,' 1865, pp. 593—617, figs. 1—8). The scapula (*op. cit.*, figs. 3—6) is like that of *Caprimulgus*, but larger and more delicate; the coracoid is short; the meso-coracoid process is small in *Cypselus* (figs. 1 and 2), large and distinct in *Chætura* (fig. 3). The epicoracoid spur is absent, and this part is but little produced.

The furcula (figs. 1—8) agrees with that of *Caprimulgus*, being U-shaped, strong, and having even a still more distinct præ-coracoid, the flat top of which abuts against the lower surface of the head of the coracoid (*op. cit.*, figs. 1—8); the inter-clavicle is also well developed, but does not come near the sternal keel in *Cypselus, Chætura,* or *Collocalia;* it nearly reaches it in *Dendrochelidon*, where it is nearly as large as in the Swallow (*Hirundo rustica*). The structure and development of the furcula answers evidently to that of the Hawk (*Nisus*), for the thick præ-coracoid wedge does not appear to have an osseous centre of its own, but to derive its bony matter from the clavicle. In Plate XIII, figs. 13, 14, I have shown the Sternum of *Cypselus apus*, magnified two diameters; fig. 14 shows it from above, and fig. 13 from the side. Its general form is wedge-shaped, being of great length, narrow in front, and very wide behind; its lateral margins are concave; its posterior margin sinuoso-arcuate; its anterior, narrow end having the oblique costal processes (c. p.) standing out like ears in front of the five costal condyles (c. c.). The rostral process is oblong, and obliquely placed between the shallow coracoid grooves (cr. g.). The keel is immense, gently concave in its front outline, and gently arcuate below; it reaches to the end of the xiphoid region, which is wholly ossified, and has a ribbed margin. Behind the coracoid grooves there is a deep (primordial) fossa, which receives the air from the contiguous cells (see fig. 14). In both figures the body of the bone is seen to be irregularly pierced with two rows of fenestræ; another double fenestra partly severs the first third of the keel from the rest (fig. 13). Before I studied Dr. Sclater's paper, I had determined the meaning of these "fenestræ," namely, as being irregular, because feeble, attempts at segmentation; the upper rows as partly cleaving the body of the Sternum into five parallel bands; and the one on the keel tending to cut up that part into succeeding segments. In *Chætura zonaris* (*op. cit.*, figs. 3 and 4) there is a very large fenestra on each side, at the junction of the costal and xiphoid regions; behind these there are several small fenestræ. In *Collocalia francica* (*op. cit.*, figs. 5 and 6) there is a similar deficiency of the bone; and Dr. Sclater mentions two openings in the keel, and quotes Mr. Gosse ('Birds of Jamaica,' p. 59) as describing a similar structure in his *Tachornis phœnicobia*. But the unique condition of the Sternum in *Dendrochelidon Wallacii* is most instructive, for this Bird has true fenestræ as large as the closed notches of *Ægotheles cristatus*. The long, oval inner fenestra runs up to the penultimate costal condyle on each side, and a little behind its middle the outer fenestra begins; it is a long, irregular triangle, and has its smallest side parallel with the broad, concave, posterior margin. The inner fenestra *half divides* the ento-sternum from the lateral parts; the intermediate xiphoid bar is narrow, and lies obliquely between the two fenestræ. Here, let it be remarked, is the greatest tendency to a morphological breaking-up of this relatively huge Sternum, in a case where, functionally, most solidity is required.

Family—"TROCHILINÆ."

The Shoulder-girdle and Sternum of the Humming-birds (see Hunt. Mus., Nos. 1519—1523) are very similar to those of the Swifts; but the strongly marked characters seen in these Birds are intensified in the *Trochili.* The scapula is long and ensiform; the coracoid is short and stout; the furcula is U-shaped, strong, and has a small inter-clavicle. The Sternum is longer than in the Swift, and widens more suddenly towards the end. I see no fenestræ; but in some kinds the body of the bone is much swollen on each side of the middle line, which is a deep groove punched full of air-holes. There is a thick *upper* "rostrum," as in the Swift; the coracoid grooves lie on each side of this process, and the costal processes are still smaller than in those Birds; the keel, in some species at least, is considerably larger, relatively, than in *Cypselus;* it reaches the end of the bone, which ends *below the tail,* as in the Tinamou,—a Bird which can lay but little claim to relationship with these Insect-like Vertebrata.

Sub-ordo—"PASSERINÆ."[1]

Examples.—Linota cannabina, Linn.; *Turdus merula,* Linn.; *Corvus monedula,* Linn.

In this group I would include the thick- and thin-billed songsters (Fringillinæ, and the allied Sub-families; Sylviinæ, and their congeners); the Crows (Corvinæ—including the old-world and Australian types, and the Birds of Paradise); Shrikes (Laniinæ); Flycatchers (Muscicapinæ, Tyranninæ); Swallows (Hirundinæ); Creepers (Certhiinæ); Tits (Parinæ), &c. A great host this, yet wonderfully uniform in osteological structure, being varied in the gentlest manner; and the cases in which the typical character are either in excess or aborted very few. It is difficult to believe that this group is not equal in a systematic sense to what I have just spoken of as the Picariæ; yet this latter group is polymorphic in a very great degree, and is most strongly in contrast with the homomorphic Passerinæ. If the Picariæ were treated as three distinct orders, namely, Zygodactyli, Syndactyli, and Heterodactyli, even then the comparison of the Passerinæ with either of these would not hold; for there is no such uniformity in any one of these lesser groups, such as is seen in the Passerine Sub-order. The only group equally homomorphic is the Psittacine Family; but this is only one amongst many members of the Picariæ. The Gallinaceæ might be compared with the Passerinæ, were it not for the Columbine, Hemipodiine, and Pterocline groups; to say nothing of the *semi-struthious* Tinamous. So that we see half of the Gallinaceous Birds diverge considerably from, or have not arrived at, the typical condition. I shall give an account of the development of the Shoulder-girdle and Sternum in a typical Passerine Bird, namely, the Brown Linnet (*Linota cannabina*); in the Blackbird (*Turdus merula*); and in the Daw (*Corvus monedula*).

In *Linota,* when two fifths of the incubating period have elapsed, the coraco-scapular structures appear as shown in Plate XV, fig. 12 (magnified twenty diameters): this view is from the inside. The scapula (sc.) is a broad falchion-like cartilage; out-turned, broad, and then pointed in its supra-scapular region (s. sc.): at its base it is separated from the coracoid (cr.) by a sharply defined, undulating, transverse cleft (s. sc.), which passes through the middle of the glenoid concavity (gl.) to the emarginate meso-scapular projection ("acromion," m. sc.). A delicate

[1] Professor Huxley ('Proc. Zool. Soc.,' 1867, p. 450) proposes to add the Goatsuckers, Swifts, and perhaps also the Humming Birds, to the Passerine group, and to call the whole sub-order "Œgithognathæ:" it is a great relief to my mind to have the Swallows and the Swifts thus made to "atone together."

ectosteal layer forms a jagged ring round the neck of the scapula, and a larger ensheathing bony layer has appeared round the body of the coracoid (cr.). This latter part is moderately broad, and has its head down-turned in front, and its epicoracoid base (e. cr.) greatly expanded. From the meso-scapular projection (m. sc.) there has been segmented a tear-shaped mass of soft, clear cartilage, the "meso-scapular segment" (m. sc. s.), and from the down-turned head of the coracoid a heart-shaped segment of somewhat denser hyaline cartilage has been freed: this is the præ-coracoid segment (p. cr. s.). In the perichondrial stroma (p. r.) which passes as a band downwards towards the mid-line of the body, there has been a styliform mass of bony matter deposited: this is the first appearance of the clavicle (cl.); it is altogether distinct in substance and in essence from the two cartilaginous segments. At this time the two halves of the Sternum have begun to coalesce, their outer margins having already been cleft from the sternal ribs. In a few more days, two or three before hatching, the embryo has undergone great changes; these are figured in Plate XV, figs. 13—15 (fig. 13 is magnified eight diameters, and figs. 14 and 15 twenty-four diameters). The scapula (sc.) has acquired a more perfect shaft, and is more that of the adult, so also is the coracoid (cr.): both these parts are much more slender, and like the finished bone of the adult. The clavicle (cl.) has reached its fellow below, and at this junction an inter-clavicle (i. cl.) has been formed; above, the clavicle has entered the meso-scapular segment (m. sc. s.), ossifying it, and being at present surrounded by it upon the upper third, the hyaline cartilage forming an embracing loop, which will soon be converted into the upper part of the furcular ramus. The præ-coracoid segment (p. cr. s.) is co-extensive, vertically, with the meso-scapular; but it juts out transversely into a large rounded lobe of flat, consistent, hyaline cartilage, like the blade of a hatchet, with the *edge*, however, lying against the *haft* (figs. 14, 15); for since the last stage this piece has grown forward so as to lie in front of the clavicle, to the antero-external edge of which it is attached by connective tissue. This autogenous præ-coracoid continues soft until the young Bird is wellnigh fledged; the mode of its ossification is endosteal, as is shown in the furcula of *Corvus monedula* (fig. 19, p. cr. s., cl.): in a few weeks, after becoming quite ossified, it coalesces with the clavicle, to form the anterior lobe of the two-eared furcular ramus.[1] The tissue round the inter-clavicle is not sufficiently developed in the Passerinæ to show a *distal* præ-coracoid, although this is the part where it should appear, and where it can be demonstrated in the Gallinæ. The Sternum of the Linnet at this stage is very similar to that of the adult; the rostrum (r.) is long and well forked; the costal processes (c. p.) are broad and oblique; the keel (k.) is at present low; the narrow external xiphoids (e. x.) are very divergent; the middle xiphoid (m. x.) has a large primordial notch, and the coracoid grooves (cr. g.) are well-grown and distinct from each other, a notable raphe being visible between them at the mid-line. In the adult all the parts have become intensely ossified in condition, and extremely elegant and slender in form; the scapula has become a very narrow, curved, pointed

[1] The compound nature of the Passerine furcula was long since known to Nitzsch. (See his article "*Passerinæ*," Ersch und Grüber, 'Encyclopädie,' Section iii, Theil 13, 1840.) He says, "In all Passerinæ the furcula is very remarkable for a lamellar handle (Griff), directed backwards, and for expanded hammer-shaped upper ends. This expansion of the upper ends arises from the addition of a special bone, which eventually coalesces with the furcula, which I have called *epicladium*, and with which Geoffroy St. Hilaire was already acquainted. It is found elsewhere only in the Wood-peckers and the King-fishers." This restriction of the development of the "epicladium" (proximal præ-coracoid) is a mistake; it is generally present in the Carinatæ.

sword, and at its base the "acromion" is large and widely bifurcate. The coracoid has acquired great slenderness of the shaft; a more down-turned head; a very rudimentary meso-coracoid process; a flat triangular posterior epicoracoid lobe; and a *hooked anterior lobe,* the counterpart of the distinct epicoracoid bone of the Monotreme.

The Sternum has acquired a very large keel, and the front of the bone is divided by a broad and rather shallow notch into two equal parts; the lower belonging to the keel, and the upper to the rostrum. This latter part is very large, looks more upwards than forwards, is strongly carinate antero-inferiorly, is thick and round above, towards, and along its strong forks, and scooped below, where its base becomes coincident with the lower coracoid lip. The upper lips form part of a strong, low, transverse wall, running from one costal process to the other; these latter processes have become sharper, longer, and more forthstanding. The xiphoid notch (one on each side) is half the length of the Sternum; it is triangular, and very large: the external xiphoid process is long, very narrow, pedate; and does not diverge so much as in the embryo. The body of the Sternum is angularly deep; the middle xiphoid plate has its notch filled up, and its posterior margin slightly arcuate, and developed into eared corners, tending to bound-in the notch. On the right side of the anterior part of the great notch there are (in the specimen before me) two small fenestræ; these show a disposition to a further fissure of the Sternum, and are seen in many of the Fringillinæ, and in other Passerines. There are five costal condyles on each side; the Sternum, like the other bones, except those of the skull of this and most other small Birds, does not admit air, as has been frequently stated by Dr. Crisp (various places in 'Proc. Zool. Soc.'): the tables of the bone nearly meet, and the margins are everywhere thickened by solid bone. The furcula of the adult Bird is extremely elegant; the delicate rami become arcuate below their middle; the *compound* upper part is very broad, and is emarginate above, and the inter-clavicle has grown into a large, oblong plate, directed equally upwards and backwards so as to touch the keel of the rostrum.

In Plate XV, fig. 16, the Shoulder- and Breast-bones of the Blackbird (*Turdus merula*) are shown, as seen from below, magnified ten diameters; these are at nearly the same stage as the parts of the second embryo of *Linota* (figs. 13—15). The scapula (sc.) is much less pointed; the coracoid (cr.) is more massive; the præ-coracoid segment (p. cr. s.) is seen wedged in between the clavicle and head of the coracoid; in a side view it would appear projecting forwards. The clavicles (cl.) have united to form a U-shaped furcula, at the angle of which a small inter-clavicle (i. cl.) is seen. As in *Linota,* the Sternum is broader than long; it has one pair of notches, which are, however, almost converted into fenestræ by the outspread (pedate) ends of the outer and middle xiphoids. This latter plate (m. x.) has already an arcuate outline behind, and the former (e. x.) is very broad and expanded. The costal processes (c. p.) are angular; there are five pairs of condyles (c. c.); the keel (k.) is low, and outspread behind; and the rostrum (r.) is rather shorter than in *Linota.* Fig. 17 gives an oblique side view of the Sternum of a fledgling Blackbird (magnified two diameters); and in it are seen the three typically Passerine osseous centres. Each "pleurosteon" (pl. o.) reaches—fore and aft—from the end of the costal process (c. p.) to the verge of the xiphoid notch; below it has met the azygous "lophosteon" (lo.) which ossifies part of the body of the bone, the rostrum (r.), and the whole of the keel (k.). Already the xiphoids (m. x., e. x.) are wider apart, and the whole of the Sternum is more oblong; in the adult this becomes intensified, and then the largely pedate external xiphoids stand well forwards as well as upwards, these processes becoming almost as far advanced as in the Gallinaceæ. In the

Australian genus *Cinclosoma* (*C. Lathami*, Hunt. Mus. 1590) we have a Passerine Bird with the outer xiphoid as much advanced as in the Gallinæ; whilst in *Anthochæra carunculata* they lie back, nearly parallel with the broad meso-xiphoid, and separated from it by a narrow slit-like notch: this is isomorphous with what we see in the Lamellirostres. In some of the Australian Passerines, e. g. *Petroica bicolor* (Hunt. Mus., No. 1584), and *Dasyornis australis* (Hunt. Mus., No. 1531), the furcula is very feeble, and the inter-clavicle is aborted; in these forms the outer xiphoid is nearly parallel with the middle plate, as in *Anthochæra*. In the Butcher-bird (*Lanius collurio*) there is an *inner fenestra* on the right side one twenty-seventh of an inch in extent; it is near the end of the Sternum. In the Nuthatch (*Sitta Europæa*) there are two similar fenestræ, one on each side, these are opposite the angle of the large notch; and there is an additional smaller passage on the right side. Both *Lanius* and *Sitta* are "outsiders," with regard to the group, and so are the Tits (Parinæ); it is in this latter Family, however, that the most perfect additional sternal cleft may at times be seen. Plate XVI, fig. 1, shows an under view of the Sternum of *Parus cæruleus*, magnified three diameters; here is to be seen a well-formed, transversely oval, inner notch (i. n.); in this case, on the left side only; the typical characters of a Passerine Sternum are, in other respects, well developed: the keel on the rostrum (r.) quite distinct from the keel on the body of the bone, is clearly displayed. At first sight the Crows (Corvinæ) appear to be but little severed from the Finches (Fringillinæ): but in their development they show the greatest departure made by any Family of this Sub-order. In Plate XV, fig. 18, the Shoulder and Breast-bones of a fledgling Daw (*Corvus monedula*) are shown, of the natural size; fig. 19 shows the furcula (two diameters); and fig. 20 a section of the sternal keel (ten diameters). The scapula (sc.) and coracoid (cr.) are quite typical, and so is the furcula (fig. 19), which is here in an instructive stage, showing the complete absorption of the meso-scapular segment by the tip of the clavicle (cl.), and the endosteal patch (en. o.) inside the substance of the solid hyaline cartilage into which the præ-coracoid segment (p. cr. s.) has been converted; the inter-clavicle (i. cl.) has its proper semilunar form, but will extend much farther backwards in the adult. If figs. 17 and 18 be compared, it will be seen that the Crow has an additional pair of sternal ossifications to what is found in *Turdus* (which agrees with the Passerinæ, generally); in the Daw (fig. 18) there is a metosteon (m. o.) on each side, behind the pleurosteon (pl. o.); and the lophosteon (l. o.) only ossifies the keel (k.), as is more clearly shown in fig. 20. The greater extent of the *inner* than the *outer* bony deposits, shown in all these figures, indicates their original endosteal character. In the adult Crow the great middle xiphoid plate is sinuoso-transverse behind; in the Australian type, e.g. *Gymnorhina tibicen*, I find a considerable semi-oval (primordial) notch at the mid-line, answering to that of the embryo of the Linnet (see Plate XV, fig. 13, m. x.). This is in perfect harmony with the generalised nature of these *Austro-corvinæ*, which have a skull and face coming very near to what is seen in the Toucans (*Ramphastos*) and the Hornbills (*Buceros*).

Sub-ordo—"GALLINÆ."

Examples.—Phasianus colchicus, Linn.; *P. gallus*, Gmel.; *Numida meleagris*, Linn.

For a description of the Shoulder- and Breast-bones in the adult Gallinaceous Bird I must refer the reader to my paper in the 'Zoological Transactions' for 1864, vol. 5, pp. 149—241.[1]

I see no reason for modifying the classification used in that paper (see p. 155); with regard to the Tinamine Sub-order, when these Birds have acquired a Gallinaceous skull and pelvis, and when their long *intermediate* xiphoids have acquired an *outer* fork; then, and not till then, can they be classified otherwise than as a *Gallo-struthious* group; they appear to be a sort of Ostriches—intermediate between the *Apteryx* and the *Rhea*—in the act of passing into the Gallinaceous territory, by way of the Hemipods. Nevertheless, these Birds undergo an amount of metamorphosis, which forbids them from being placed with the typical Struthionidæ, and yet they retain an abundance of true Struthious characters, leaving them in the closest vicinity with those low and, as it were, embryonic or Reptilian types.[1] As to the Shoulder-girdle and Sternum of the typical Gallinaceous Bird, my earliest illustrations are from the common Pheasant, that is, after nine days of incubation (see Plate XVI, figs. 2—7;—figs. 2 and 4 are magnified six diameters; fig. 3 twenty-four diameters; and figs. 5—7 forty diameters). The scapula (fig. 4, sc.) is narrow, blunt at its supra-scapular end, which part is somewhat recurved; the rest of the bar being gently arcuate. Half the bar is enclosed by an endosteal sheath, and this is nearer the small blunt acromion (m. sc.) than the distal end. A clearly defined transverse cleft has already severed the scapula from the coracoid (cr.); this passes through the shallow glenoid fossa (gl.). The head of the coracoid is greatly extended forwards, and its shaft, already enringed with a delicate bony layer, is very narrow; its broad, flat, six-sided epicoracoid region (e. cr.) is, like its head, still unossified. There is some delicate cartilage near the end of the acromion, this is the "meso-scapular" segment (m. sc. s.); another patch, lunate in shape, is severed from the projecting head of the coracoid; this is the "proximal præ-coracoid segment" (p. cr.). Neither of these acquire much consistency, the former becoming rapidly ossified from the end of the clavicle (see fig. 5, m. sc. s., cl.), and the latter becoming converted into the ligament which ties the clavicle to the coracoid. Below the junction of the clavicles there is a double layer of delicate fibro-cellular stroma; this is more transparent than ordinary connective tissue in its nascent condition; but it never becomes converted into true hyaline cartilage. This mass, into which the

[1] It will be seen that I have changed the nomenclature of the parts; and with regard to the bones of the Shoulder especially, many newly discovered elements have to receive names in the present paper. I have retained the term "ento-sternum" for all the mesial part of the breast-bone; for "episternal process," I use the term "rostrum;" for "hyo-sternum," "costal process" and "costal region;" to the "hypo-sternum" of former papers, as well as to the terminal part of the ento-sternum, I now apply the term "xiphoid process." With regard to the ossific centres, their nomenclature is entirely new; and some of them, viz., the two "coracostea," and the "urosteon," are now described for the first time.

[2] Professor Huxley ('Proc. Zool. Soc.,' 1867, p. 425) puts these inosculant forms into a separate Sub-order, namely, the Dromæognathæ: his views will be seen to coincide very closely with mine.

clavicle and inter-clavicle grow (see figs. 6 and 7, cl., i. cl., d. p. cr.), is the counterpart of the right and left " distal præ-coracoids," which are so frequently developed in the Mammalia.[1]

At this stage the Sternum (fig. 2) is very instructive; it is almost divided by deep notches into six sub-parallel bands of cartilage. The broadest as well as the longest bands meet at the mid-line. They (e. s.) are separated by the primordial ventral fissure, which is rapidly disappearing; it has, however, left an emargination in front and a long slit behind. Each half of this double band, nearer the end than the front, has sent down a delicate lamina; these laminæ have coalesced below; the result is the sternal keel. A section taken towards the front of the rudimentary keel (fig. 3, k.) shows the primordial fissure, not yet filled in, above. The lower coracoid lip (fig. 2, cr. g.) is seen to be an "outgrowth" arising behind the inner margin of a large deep notch, separating the rostrum (r.) from the costal process (c. p.); a moderately broad isthmus separates this front notch from the large open cleft which divides the "intermediate" from the "middle xiphoid" (i. x., m. x.). Another notch, two thirds the size of the former, separates the outer (e. x.) from the intermediate xiphoid. The external xiphoid diverges very much from the other, and is largely pedate, looking fowards and upwards, and embracing the ribs. In front of the outer xiphoid, and mounting up the costal process (c. p.), there are four costal condyles (c. c.). The whole of this multifid Sternum of the embryo Pheasant is, and will be for some days to come, entirely soft. A day later, in the chick of the common Fowl, a much larger mass of meso-scapular hyaline cartilage (fig. 9, m.s.c.s.) can be seen receiving bony matter from the clavicle (cl.); and in fig. 8 it is seen that the clavicles have begun to coalesce, and that the inter-clavicle (i. cl.) is much smaller than in the Pheasant; it is imbedded in a delicate mass of fibro-cartilage—the distal præcoracoid (d. p. c. r.). The next important stage in the Sternum is shown in the common Chick, two or three days after hatching (figs. 10 and 11 magnified three diameters; fig. 11 is a side view of the Sternum of a chick a day or so older than that shown in fig. 10); here we have the five bony centres that appear in the typical Gallinaceous Birds.

These osseous patches appear earlier, are much more definite in outline, and disappear later than in Birds generally, the reason of this being that they are ectostoses; and this mode of ossification of the Sternum has not been seen since we first came across it amongst the higher tailless Batrachians, for instance, *Rana* and its nearest congeners. The five centres are synchronous or nearly so; each costal process (c. p.) and region (c. c.) is ossified by a pleurosteon (pl. o.), the strongly-forked outer xiphoid (e. x., i. x.) by a metosteon (m. o.), and all the ento-sternal region, from the rostrum to the middle xiphoid by the lophostéon (l. o.). A section through the anterior part of the lophosteon shows (see fig. 12, magnified ten diameters,) the dense ectosteal layer, which is growing inwards, and is seen to fill up the (primordial) fissure above, and to be creeping down the cartilage (c.) of the keel below. The general form of the Sternum has changed in some respects; the two coracoid lips (cr. g.) are more nearly equal; the more extended rostrum has acquired a fenestra (r. f.), which partly cleaves it from the rest of the ento-sternum. I have already shown that this cleft appears in *Upupa epops* and in *Buceros albirostris*. The intermediate xiphoid (i. x.) has acquired a "foot," and the middle bar (m. x.) is now one piece; the keel (k.) is deeper, and it sends forwards a sharp hook at its angle; the keel

[1] This is only one among many instances in which the Bird adumbrates the Mammal, rising indeed to almost the same morphological height; and only lying *obliquely between* the Reptile and the Mammal.

retires very much from the rostrum; this is a marked Gallinaceous character, well seen in the heavy Turkey.

The appearance of the Sternum of a typical Fowl at six weeks old is shown in Plate XVIII, fig. 1; it is that of the Guinea-hen (*Numida meleagris*). The figure is of the natural size. The keel (k.) is much deeper, and the osseous centres are beginning to meet; the form of the parts may serve to illustrate a medium, typical Sternum in this tribe. The "meso-scapular segment" is more independent in some of the sub-typical kinds, for instance, in *Tetrao cupido* (Plate XVIII, fig. 3, m. sc.); this figure also shows the large inter-clavicle, which grows backwards and upwards from the angle of the conjoined clavicles (cl.). These descriptions of the development of the Shoulder- and Breast-bones of the Pheasant, the Fowl, the Guinea-hen, and the Pinnated Grouse, must serve for the Phasianinæ, Tetraoninæ, Cracinæ, and Megapodiinæ; it is probable, however, that in these last two aberrant groups there may be, in spite of the similarity of outward form, some important differences in their osteogeny. The group next to be described will serve to illustrate this remark, and to show that guess-work is worse than worthless.

Family—"HEMIPODIINÆ."[1]

Example.—*Turnix rostratus*, Swinhoe.

For a description of the Shoulder- and Breast-bones in the adult Hemipod I must refer the reader to my paper on the Gallinaceæ (p. 184, Plate 35). The subject is *Hemipodius varius* (Hunt. Mus., No. 1423). All the parts are much slenderer and more elegant than in the young. In the *pin-feathered* young of *Turnix rostratus*[2] the scapula has still a large supra-scapular cartilage (Plate XVI, fig. 14, s. sc.), it is very long, narrow, and gently arcuate; the coracoid (cr.) is very long, narrow-shafted, has a definite meso-coracoid plate (m. cr.), an arched head, and a semilunar epicoracoid (e. cr.), still soft. The furcula (fig. 14, cl., i. cl.) is V-shaped, has narrow rami, which curve backwards where they join the still separate interclavicle (fig. 16, i. cl.); this latter bone is oval, like a little seed; it becomes converted into an upturned square plate in the adult (*op. cit.*, Plate 35, fig. 5, fr.). The "meso-scapular segment" (fig. 15, m. sc. s.) crowns the head of each clavicle; it is composed of consistent hyaline cartilage; the præ-coracoid segment has become a "coraco-clavicular ligament." The Sternum is very broad and short, and much unlike that of the adult in this respect (*op. cit.*, Plate 35, fig. 6), for the bone in the adult comes very close to that of the Tinamou (*op. cit.*, Plate 41, fig. 1). The difference between the Sternum and that of the typical Fowls is well seen in my illustrations (compare fig. 13 with fig. 10): the lateral xiphoid (e. i. x.) being simple, instead of having the bilobate form seen in typical Fowls.

The coracoid grooves (cr. g.) are some distance apart; the rostrum (r.) is large, thick at

[1] I am indebted to Robert Swinhoe, Esq., H.M. Consul, Formosa, for three very young specimens of *Hemipodius* (*Turnix*) *rostratus*. They came to me well preserved in spirits, and are a great treasure.

[2] Figs. 13 and 14 are magnified four, 15—17, ten, fig. 19, twenty, and fig. 18, one hundred diameters.

the top, keeled below, and imperforate, unlike the true Gallinæ. The keel is large; it retires very much in the young, but comes well forward in the adult (*op. cit.*, Plate 35, fig. 5, e. s.); and the post-costal part of the ento-sternum is a narrow wedge in the adult, but a very broad one in the young (Plate 16, fig. 13, m. x.). Hence the space between the pointed ento-sternum and the long, incurved, pedate, outer bars (e. i. x.) is very large and triangular; this space answers to the *inner notch* of the typical Fowl; and the outer xiphoid of *Turnix* answers to both the "external" and the "intermediate" xiphoids of the typical form in an undivided state. The costal processes (c. p.) are broad and recurved, and behind them come four condyles; the last of these receives the sternal rib of the last dorsal vertebra (fig. 13). Behind this there is a floating rib, which belongs to the first lumbo-sacral arch, as in the common Fowl; but in the typical Fowl and in *Crax globicera* this floating rib has the rudiment of an abdominal rib continuous with it. This is not seen in *Turnix*. In *Talegalla Lathami* there is on each side a much more perfect abdominal rib (Plate XI, figs. 12, 13, a. r. 1); this is only partially segmented from the sternal rib in front of it (which here reaches the Sternum) by a notch in the young, which becomes a fenestra in the adult. On the right side (Plate 11, fig. 13, a. r. 2) there is a small second abdominal rib. The same thing occurs in the *Palamedea*, with this modification, viz. that there is no abdominal rib at all on the left side.[1]

The ossification of the Sternum of *Turnix* is ectosteal, as in the Fowl; a section of the keel shows this (see fig. 19, magnified twenty diameters, and fig. 18, one hundred diameters). The endosteal deposit (en. o.) is indeed taking place *pari passu* with the ectosteal, but the latter was the first to appear: the former takes place as in the cold-blooded types, that is, the calcareous deposit affects the inter-cellular substance, whilst the cartilage cells become *immediately* transformed into osseous "lacunæ." This ectosteal character of the bony centres is of the greatest consequence, as it keeps our Hemipods safe amongst the Gallostruthious types; but another, and unlooked-for peculiarity presents itself in the *number* of these bony patches. Happily for me, these young Hemipods were secured at the same stage of ossification as the Chicks, half a week old, which have been already described: the bony centres were small, and thoroughly distinct (see Plate XVI, figs. 13, 14). Here we see again the "pleurosteon" (pl. o.), the "metosteon" (m. o.), and the azygous "lophosteon" (l. o.): but the last centre has on each side a new bony patch, which from its relation to the coracoid lips and groove (cr. g.), I propose to call the "coracosteon" (cr. o.). These three entosternal centres are the largest and the *earliest*, whilst the metosteon is the least and latest.[2]

[1] I mention this to show that the Gallinaceous relatives of the Palamedeas are to be sought for amongst the Megapods as well as amongst the Cracinæ; and also the great distinctness of the Hemipod type from the true Gallinæ: the Hemipodiine Family is interposed bodily between the Tinamous and the true Gallinæ. As for the *Talegalla*, the figures above referred to (three fourths of natural size), show how truly Gallinaceous it is with its huge external xiphoid (e. x.) so widely severed from the smaller intermediate bar, as in *Crax* and *Meleagris;* its rostrum also is *fenestrate;* a good touchstone of the degree of Gallinaceous affinity.

[2] It is worthy of remark that the ossification of the sternum in the Hemipods is very late, as compared with the Fowl; for these young Birds were apparently two or three *weeks* old; and as many *days* would seem to bring the deposit to the same stage in the common Fowl. In the Struthionidæ proper, the centres are much more advanced before hatching (see Plate XVII, figs. 3, 4, and 7); but

These "coracostea" speak the same language as the anterior and posterior notches, and tell of the essentially *quinquefid* nature of the Bird's Sternum; and the innermost bar of the five is primarily double or symmetrical, and retains in many instances marks of its early separate condition. Some of the most interesting modifications of the Shoulder-girdle and Sternum of the Gallinæ are to be seen in the Pterocline and Columbine Families; the latter is merely a specialisation of the former, the Pigeon ascending amongst the "Altrices" from the Sandgrouse, just as the Ibis and Stork ascend from the Pluvialine "Præcoces." Moreover, the Sternum of the Sandgrouse and the Pigeon bridges over the space between that of the Gallinaceous Bird and the Plover, by means of its small inner notch ('Trans. Zool. Soc.,' 1864, Pl. 41, fig. 4, x. s.). Compare this with what is shown in the Partridge's Sternum (fig. 9). In the Sandgrouse the external xiphoid fork is not more backwards in its direction than in the Pigeons. In the Columbinæ (see Plate XVI, figs. 20, 21, which show the sternal keel of a young Pigeon magnified eight and one hundred diameters), the ossification of the Sternum is endosteal, as in Plovers and Birds generally; the ectosteal layer not appearing until some time after the endosteal deposit.[1]

Sub-ordo—"TINAMINÆ."

Example.—Tinamus robustus, Scl.

I must refer to what I have already written on the osteology of the Tinamous (*op. cit.*, Plates 39 and 41, fig. 1, pp. 225—229), but I think I may boast of having received clearer light upon the subject since that time.[2]

Notwithstanding their perfectly Struthious skull and face, and their essentially Struthious pelvis, the Tinamous, like the Fowls, are ornithically typical in their Shoulder-girdle. The broad-ended scapula (*op. cit.*, Plate 39, sc.) is quite segmented from the coracoid, and is articulated with it at an *acute angle:* it has also a free acromion process, from which a small meso-scapular segment has been cleft, the distinctness of which can be seen in the adult, it having been ossified in some degree independently of the clavicle. A very small "præ-coracoid segment" has added substance, but not by independent deposit to the shoulder of the clavicle. The furcula (*op. cit.*, Plate 41, fig. 1, f. r.) is very small and U-shaped, and has no trace of an inter-clavicle, such as is seen in *Syrrhaptes* (fig. 4, f. r.). The coracoid (cr.) is moderately long and stout, and becomes broad in the epicoracoid region, both in front and behind. The head

this has to do with the longer period of incubation. In the *Talegalla*, as Mr. Bartlett informs me, the term of incubation is at least double that in the common Fowl; and the chick, Minerva-like, comes out fully accoutred,—like a full-grown bird.

[1] For an excellent account of the Dodo's skeleton, with its *free* clavicles, and its common "meso-intermediate xiphoids," I must refer the reader to Professor Owen's paper ('Zool. Trans.,' 1867, pp. 49—85, pls. 15—24). In a Sternum belonging to S. Flower, Esq., of H. M. 13th Regiment. I find a meso-xiphoid (primordial) notch, not figured in Professor Owen's paper (see pl. 18). In that paper (pl. 15, fig. 2, and pl. 24, fig. 1) it is seen that the *inner notch* is lost in the adult *Didunculus;* these figures are from a specimen dissected by me and lent to the author.

[2] I have in my collection the skeletons of *T. robustus*, *T. variegatus*, and *T. brasiliensis* sive *major*, all of my own preparing; the subjects came to me, through Dr. Sclater's kindness, from the Gardens of the Zoological Society.

of the coracoid is strongly incurved, and the meso-coracoid (*op. cit.*, fig. 1, cr.) runs up to the acromion, and is present, as a distinct ridge, down the inside of the bone, as in Psophia, but not to the same degree. The coracoids do not meet on the front of this, the most extraordinary ornithic Sternum, and the lower lips of the coracoid groove (*op. cit.*, Plate 41, fig. 1) are separated by a primordial notch, whilst the earlier-formed inner lips are separated by a strong forthstanding, flattened upper rostrum (see also Plate XVIII, fig. 2, r, of the present paper, to which my references will now also be made). Behind the oblong, almost erect costal processes (c. p.), there are three condyles for sternal ribs (s. r.); there are four in *T. variegatus* and *brasiliensis.* Close behind the last condyle, the long outer xiphisternal bar (e. i. x.), which answers to the forked bar of the Fowl, passes backwards, and is elegantly *f*-shaped. It is of extraordinary length, and reaches, like the entosternum, to the same vertical line as the root of the tail. The isthmus which connects the lateral parts to the ento-sternum is only half an inch in extent; thus the main part of the bone is divided into three very long narrow bands (see also *op. cit.*, Plate 41, fig. 1, e. s., hy. s.), the middle part being thrice the width of each of the delicate sinuoso-arcuate bars. The keel (k.) is very deep, and does not retreat as in the Fowl, but stands well forwards as in *Hemipodius* (*op. cit.*, Plate 35, fig. 5, e. s.), only a small space is left at its anterior, somewhat *acute* angle, for the "pectoralis major" muscle; nevertheless, as in the "Raptores diurnæ," these muscles swell far beyond the keel, and in actual mass are enormous. Altogether, these muscles are, relatively, almost as large as in the Swift (*Cypselus apus*); but their substance is pulpy, and their colour a faint greenish-white, quite Reptilian in character.

Ordo—"STRUTHIONINÆ."

Examples.—Struthio camelus. Linn.; *Casuarius Bennettii,* Gould; *Dromæus irroratus,* Bartl.; *Rhea Americana,* Lath; *Apteryx Australis,* Shaw.

In the lowest types of Water-Birds (for example, the Penguin and the Cormorant), we encountered nothing in the structure of the Shoulder-girdle that was not essentially typically ornithic: here, however, in the true Ostriches, we have the simple characters of the Chelonian Shoulder-bones back again. Now, it might be said that this was dependent upon the enfeebled condition of the wings; but this argument will not serve, for we have a similar Reptilian simplicity in the Shoulder-plate of the Monotremes, and they have large fore-limbs. The earliest condition that I have of these parts is in *Struthio camelus* (*Struthio* "A" of my paper on the Skull: see 'Phil. Trans.,' 1866); the embryo was the size of a Sparrow; the figure (Plate XVII, fig. 5) is magnified two diameters. The coraco-scapular cartilage answers very closely to that of an embryo Tortoise, save that the scapula (sc.) is flattened; it is nearly as straight, has the same breadth, and bifurcates in the same manner into a coracoid (cr.) behind, and a præ-coracoid (p. cr.) in front. The only trace of a meso-scapula is in the oval convexity which is seen mesiad of the glenoid cup (gl.); but there is no other cleft than the one figured as almost dividing the two coracoid bars; this notch (cr. n.) enlarges above, but is a mere slit below. The præ-coracoid is clubbed below; but the coracoid is pedate, the greatest enlargement being on the inner margin; this outspread front hook is large in the Monotremes, and has its own ectosteal bony patch—the epicoracoid: I have already described this inner hook in the Linnet. When the embryo half fills the egg-shell notable changes have taken place in the Shoulder-plate, although the Sternum has increased principally in size and convexity, but without any ossific deposit. The scapula (fig. 6, sc.) has acquired an ectosteal coating, leaving a somewhat curved supra-scapula (s. sc.) still soft; the meso-scapular and glenoid (gl.) regions also are still unossified. The waist of the hourglass-shaped coracoid (cr.) is invested with bone, leaving the head and the epicoracoid regions (e. cr.) still soft. The large Chelonioid præ-coracoid (p. cr.) will receive its bony matter direct from the scapular shaft, exactly as in the Chelonians; the cleft (cr. n.) between the two bars is extremely narrow below, but has expanded above. No morphological changes will take place in this two-legged bar; but, histologically, it will be modified by complete conversion into bone, without adding any new centres. There is no clavicle in *Struthio;* the large anterior bar is the lump out of which morphological change (metamorphosis) might have modelled the "meso-scapular" and "præ-coracoid segments." The Sternum (fig. 5) soon acquires its permanent outline; it is oblong, but pinched between the costal condyles (c. c.), and then quickly expands to form the external xiphoids (e. x.), which are rather broad, arcuate, and pedate; they are separated from the middle xiphoid (m. x.) by a large, rounded notch; this process has its own convexity, distinct from that of the main part of the ento-sternum; it is tongue-shaped, and projects further backwards than the outer bars. There are five condyles (c. c.) surmounted by an angular costal process (c. p.); the coracoid grooves (cr. g.) are some distance apart, and are separated by the rudiment of a notched rostrum. I have not seen more than two ectosteal patches in the Sternum of *Struthio* (Hunt. Mus., No. 1366); but I have at hand no specimen near hatching time to settle this point; for secondary or smaller centres soon coalesce with the main pieces. The Sternum of *Struthio* becomes completely ossified in old age, and a pair of small inner notches appear behind, separating the intermediate xiphoids from the middle process. The sternal ribs (s. r.) are still soft in the youngest *Struthio;* but ossification has commenced in the vertebral ribs (v. r.).

In the ripe chick of the Mooruk (*Casuarius Bennettii,* Plate XVII, fig. 3, magnified to one and a half diameter, and from below), we see a very long, slender, sinuoso-arcuate scapula (sc.), almost ossified, with a soft blunt-pointed supra-scapula (s. sc.); the swollen meso-scapular and glenoid (gl.) base is also soft, as is also the beak-like, arrested præ-coracoid. The coracoid, which is smaller than in *Struthio,* runs in the same curved line as the scapula, but makes no angular bend; its substance is pierced to form the usual foramen, and its base (e. cr.), still soft, is broadly pedate; from the deficiency of the præ-coracoid bar the "notch" is widely open below.

The right clavicle is two and the left one and a half lines in length (fig. 3, cl.); they are spindle-shaped, and are perched up on the mesial side of the præ-coracoid, this being the place where the skin at the base of the neck is tucked in, expanding again over the thorax. These bones form no morphological union with the endo-skeletal parts of the thorax; but continue as independent as in the Lizards. The Sternum is heart-shaped, and is tolerably convex all over its lower surface; its costal processes (c. p.), and condyles (c. c.) project furthest outwards; the former is not much larger than the latter, of which there are five. The coracoid grooves are large and symmetrical; the outer lip is a manifest "out-growth," and each terminates in a rounded elevation; between these there is a large primordial notch. The xiphoid region forms two thirds of the Sternum; it suddenly narrows behind the fifth costal condyle; it then bulges, and narrows again; after this, there is an ear-like expansion, the cartilage then taking on a symmetrical, faintly five-lobed form, which projects backwards considerably. The outermost convexities answer to the outer xiphoid forks (e. x.) of the Fowl; the next to the intermediate (i. x.), and the semi-oval mesial lobe to the middle xiphoid bar (m. x.). Mesiad of each costal region an ectosteal centre has appeared—the "pleurosteon" (pl. o.); it has spread to the front margin, and into the xiphoid region; and the two centres cover two thirds of the anterior part; they also have reached the upper surface: these two are all the bony centres that will appear. The posterior margin continues soft for a long while, even in the adult, and the bony matter spreads backwards in a lobate manner; the whole bone, also, becomes relatively longer, and steeper in its sides.

In the Emeu (*Dromæus irroratus*) these parts are very similar to what we see in the Cassowary (see Plate XVII, fig. 4, which shows the lower view of the Sternum of an embryo one week before hatching, magnified to one and a half diameter). The narrow, feeble Shoulder-girdle moiety has a similar gentle curve, which becomes very little more pronounced, even in old age; the scapula (sc.) has, at this stage, a very short, rounded, soft supra-scapula (s. sc.); and below, there is a broad mass of hyaline cartilage connecting the pith of the scapular shaft with that of the coracoid (cr.); this mass is slightly hooked to form the rudiment of a præ-coracoid (p. cr.). The coracoid is a small phalangiform ray, narrower than in the Mooruk, and not having a foramen; the epicoracoid base (e. cr.) is of small extent, it is soft at present, and of a semilunar form. The clavicles (cl.) are twice as strong and large as in the Cassowary, and have the same relations; in the old Bird they have become elongated and arcuate, so that by a little more development they would have formed a furcula very similar too, but feebler than, that of the Tinamou. The Sternum is very similar to that of the Mooruk, but it is narrowest in front and widest behind; the costal processes (c. p.) are sharper, and the smaller coracoid grooves (cr. g.) overlap—the *left* below the *right;* the rostrum is faintly foreshadowed between and below these by a double pimple of cartilage. There is the same quinquelobate form of the huge xiphoid plate; but this spreads much more, especially the anterior and outer lobes (e. x.). As the right coracoid groove and lower lip is larger and further backwards than the left, so the right half of the xiphoid region is further backwards, and the largest; the primordial fissure (x. f.) is half an inch long, and is seen to separate the wide five-lobed xiphoid mass unsymmetrically. The Sternum has middle anterior convexity, and a general sinuous convexity behind; there are four pairs of costal condyles (c. c.), and a pair of ectosteal "pleurostea," as in *Casuarius*. In an Emeu six weeks old (*D. novæ-hollandiæ*), I found these to have coalesced at the mid-line, and to be creeping in a two-eared form down to the second third of the xiphoid region, which had become much more convex, had lost much of its lobate outline, and to have acquired a very elegant acuminato-ovate form, the middle region projecting in a pointed manner very far backwards. In the old bird, there is still a large unossified xiphoid margin; but it is, relatively, much broader and shorter; the bone is much more pinched behind the costal condyles; the costal processes have become long and erect, and there is a shallow fossa below, along the mid-line of the general shield-like convexity of the bone.

The feeble coraco-scapular bar of *Dinornis robustus*, Ow., is well displayed in Professor Owen's ninth paper on this genus (see 'Zool. Trans.,' 1866, pl. 55); and the Sternum of both the old and young (the latter a moiety) is beautifully shown in the photographs of the York specimens mentioned by me in my paper on the Struthious Skull (see 'Phil. Trans.' 1866, p. 163). The whole of this gently curved bar is very narrow, the scapula being the narrowest, and also twice as long as the coracoid; the præcoracoid forms a very slight projection; and if there was a minute clavicle in the recent state, it has been lost. The glenoid cavity is scarcely traceable, so that the fore-limb may have been absent. The Sternum is extremely interesting; its anterior margin is very transverse; and has on it two very irregular and shallow coracoid grooves, which are some distance apart. The costal processes are short. The first condyle for the first large sternal rib is large, the others are smaller; the costal region is of small extent. Behind the last condyle the external xiphoid begins at once to diverge; this divergence is very great; the two bars are very narrow and arcuate,—being bent inwards behind, and the notches separating them from the middle part are very large and rounded above. The middle xiphoid reaches to a less distance backwards than the outer bars, and it has a large, rounded, primordial notch; there is no appearance of an intermediate bar. The well-preserved moiety of the Sternum of a young specimen is hatchet-shaped. The almost straight external xiphoid (its curved cartilaginous end is lost) forms the handle of the ento-sternal part—the blade. The decay of the cartilage has left a deep notch, tending to separate the costal process from the rest, so that it is very probable that there was a distinct centre to that part, as in our next example—the Rhea. If this were the case, then the Sternum of *Dinornis robustus* agreed with *Struthio* in the free external xiphoids; with *Dromæus* in the oblique, irregular coracoid grooves; and with *Rhea* in the number of ossifications.

In Plate XVII, fig. 7, I have shown the Shoulder- and Breast-bones of the *Rhea* (*R. americana* crossed with *R. macrorhyncha*), at the time of hatching, and magnified one and a half diameter. The sharp-pointed scapula (sc.) is bent backwards above its base; yet the curve of the whole bar is but small. There is a triangular supra-scapular part (s. sc.), not ossified; an arcuate epicoracoid base (e. cr.), very little developed into angles; and between the scapula and coracoid (cr.) there is a tract of cartilage a line in breadth: this is scooped to form the glenoid cup (gl.) behind, and is formed into a small præ-coracoid hook (p. cr.) in front. The coracoid shaft is not pierced below the hook, but an aponeurotic tract finished the "coracoid foramen." This is completed in adult age by the spread of the periosteal growths; and at that time the coracoid has become relatively larger. Only the scapular and coracoid shaft-bones exist, and there is no clavicle; so that the Rhea agrees with the African Ostrich, the Apteryx, and probably also with *Dinornis*, in this respect. The general shape of the Rhea's Sternum is wedge-shaped; the coracoid margin, with its shallow, distant grooves (cr. g.) is very transverse; this region is terminated at its angles by the ear-like costal processes (c. p.). A wide shallow notch exists between the coracoid grooves, which bear no greater relation to the whole margin than in *Dinornis robustus;* behind the costal processes the margin swells out to form three costal condyles (c. c.); then the Sternum narrows gradually, and swells out gently in a somewhat spoon-shaped manner in the last third. There is some distinction between the middle xiphoid and the outer, the former being pointed, as in an acuminate leaf; but the lobulation is rather indefinite. The xiphoid region is very long as compared with the præ-meso-sternum, but it is not ossified separately, for already a pair of large ectosteal plates ("pleurostea") occupy nearly half the cartilage, and are only one and a half line apart, mesially; these plates have already nearly reached the posterior half of the xiphoid region. But although these plates have nearly reached the coracoid grooves, yet they do not finish the lateral præ-sternal regions (costal processes, c. p.), for here we find on each side a new osseous centre—the "pro-osteon;" an osseous element encountered here for the first time (except perhaps in *Dinornis*), but which will show itself, both symmetrical and azygous, in the Mammalia. Save in the ordinary Osseous Fishes and the Batrachia, nowhere else can ectosteal "centres" be so well studied as in the Sternum of the Struthioninæ and Gallinæ; whilst there is no mode of ossification so confused and hurried, as in the typical ornithic Sternum: the Plates show this well, for the bony laminæ are made to look as though they could be slipped off. A section through the "pleurosteon" of the *Rhea* is shown in fig. 8; and through that of the Emeu in fig. 9; both these are magnified six diameters; they both show that the outer lamina has caused the setting up of endostosis in the outermost cartilage-cells. The posterior third of the Sternum of the *Rhea* is soft, even in the adult.

In *Apteryx australis* the Shoulder-girdle is essentially like that of the Rhea, but the scapula (Plate XVII, fig. 1, sc.[1]) is rounded and decurved at the end, as in *Picus viridis* (Plate 14, fig. 21); it is also more arcuate, but the lower half of the scapula is not much bent upon the coracoid (cr.). These two bones, as shown in the half-grown bird (fig. 2, sc. cr.), are separately ossified, as usual; there is a small præ-coracoid projection (p. cr.), and the coracoid is pierced (fig. 2): the coracoid (cr.) is half the length and twice the breadth of the scapula; and the epicoracoid region (e. cr.) is more arcuate than in the Rhea. In the adult (fig. 1) the coracoid, which has become completely fused with the scapula, is very much enlarged by fibrous ossification. As in the Rhea, there are no clavicles. The Sternum is more aborted than in any other known Bird, being altogether as flat and as thin as in the Stellio Lizard; but it is wholly ossified. The ento-sternum (e. st.) is greatly cut away in front; but the great notch is double, for there is a slight pointed projection at the mid-line. The costal processes (c. p.) form two large, rounded ears; behind these the Sternum is narrowed, then the costal condyles swell out, and then comes the flat out-bent external xiphoid (e. x.), which is slightly notched on the inside, tending to make intermediate processes. The xiphoid notches are deep and rounded, and the middle xiphoid plate (m. x.) has sinuous sides; it is tongue-like, very thin, and extends several lines behind the external bars. The formation of the coracoid grooves (cr. g.) shows well their secondary nature as "outgrowths," as in the embryos of higher types; for they are entirely *outside* the rest of the Sternum; and the relation of the Shoulder-girdle to the Sternum is altogether *secondary*, and forms no part of the true axial skeleton, as the Transcendentalists vainly teach.

[1] Fig. 1 is reduced to three fourths; and fig. 2 is full size.

Class—"MAMMALIA."

Ordo—"MONOTREMATA."

Examples.—Ornithorhynchus; Echidna.

In this, the lowest group of the highest Class, we have Reptilian characters in a more remarkable degree than in any existing Bird. These characters, moreover, do not take the observer back merely to the highest types (for instance, the Crocodiles), where there is the most evident adumbration of the Mammal, but to the ordinary Lacertilia, and to the huge extinct Ichthyosaurs. As in the Reptilia and the true Struthionidæ, the moieties of the Shoulder-girdle undergo no perfect segmentation, the division of the Shoulder-plate being merely marked out by distinct *ectosteal* tracts; the *form* also of the plate is much more Reptilian than in the Bird. In *Ornithorhynchus paradoxus* (Plate XVIII, figs. 4—9), the scapula (sc.) is like a pruning hook, being moderately broad and greatly decurved; its upper or supra-scapular border (s. sc.) is merely slow in its ossification, but there is very little differentiation of it as a region: this agrees with the Bird, and with many of the Mammalia. The posterior margin of the scapula is thickened, and so is the anterior; this latter is the meso-scapular region, and it sends out a distinct bar below—the meso-scapular bar or "acromion;" the whole of this region is out-turned: there is no præ-scapula. The glenoid cavity (gl.) is shallow, oblique, and Reptilian, and in the old individual the coraco-scapular suture is not seen in its fundus, for the two main bones have totally coalesced, as they do in the Struthious Birds. The coracoid, as a whole, is a broad semilunar blade, with a short, thick shaft (fig. 6, cr., e. cr.), and the segmentation it undergoes is different from what is seen in the Reptilia. The posterior hook is but little developed, and the main shaft bone runs through nearly to the base, behind, but the anterior hook (seen in many Birds at the base of the coracoid) is very largely developed indeed: this part is not feebly ossified by endostosis, as in the Reptiles, but has its own ectosteal centre. A small margin of soft cartilage is left to the main coracoid (cr.), and a larger, thin edge to the epicoracoid (fig. 6, e. cr.): the left of these *overlaps* the right. This second, later ectosteal tract continues distinct from the earlier posterior bone (cr.). An elegant oval notch, with a small opening in front, is seen between the concave lower margin of the meso-scapula and the concave upper margin of the epicoracoid; this is the "coraco-scapular notch" (c. s. n.); it is converted into a sort of "fenestra" by the dermal bones which close the gap. There is no præ-coracoid band of cartilage, but the epicoracoid hook runs far up into that region, besides entrenching upon the meso-coracoid region below, which, like the præ-coracoid, is not here defined. The ectosteal epicoracoid is seen in the Monotremes for the first and the last time, unless it should turn up in some fossil forms; it is as interesting to the morphologist as the ectosteal supra-scapula of the Anoura.

But the endoskeletal Shoulder-arch of the *Ornithorhynchus* is but half complete by itself, for it is strongly undergirt by three "præ-thoracic" dermals, which have cropped up again from the Chelonian and the Lizard. They are in nowise diminished in relative size; and supposing these dermal bones and the inner elements of the Shoulder to have been found fossil in the Lias deposits, they would easily have been mistaken for those of a small Ichthyosaur. The symmetrical, clavicles (Plate XVIII, figs. 4—6, cl.) are of the medium size; they are *simple,* as in the Lizards, that is, they have no superaddition of endoskeletal rudiments, as in the Bird and in all other Mammals. They are dilated at the scapular end, and pointed below, where they lie upon the anterior margin of the great azygous "interclavicle." This latter bone (i. cl.) is much larger than is usual even in the Lizards; it is in shape between a T and a Y; and the arms, which are gently arcuate, nearly reach to the acromion, whilst the clavicle overlaps it behind (see fig. 4). The arms of the inter-clavicle pass insensibly into the body of the bone, which is very broad, and becomes much broader and flatter behind, where it is somewhat four-lobed.

A strong keel, rising in front, and running nearly to the end, makes this bone a close imitation of the "manubrium sterni," for which it has frequently been mistaken, whilst by others it has been taken for the furcula: it answers, however, only to the angular plate of that compound ornithic bone. The true manubrium, or præ-sternum, is as broad as the base of the overlapping inter-clavicle; it is composed of two parts, which are separated by an uncleft band of cartilage. The anterior division of the præ-sternum is only partially ossified by *endostosis;* it is firmly interlocked between the inter-clavicle and the coracoids, but is free to some extent above (fig. 6, pr. o.). This ossification is an azygous representative of the symmetrical "pro-ostea" of the Rhea, and it belongs to the seventh cervical vertebra. The transverse cartilaginous tract (figs. 5 and 6) which separates the "pro-osteon" from the first "pleurosteon" (fig. 5) is broad; the latter bone belongs to the first costal arch, and is represented in Man by the whole "manubrium." In the young *Ornithorhynchus,* this part (and perhaps also the succeeding "pleurostea") is symmetrical (see Owen, 'Catal. Hunt. Mus.,' vol. i, p. 314, 315, No. 1698). There are three more "pleurostea;" all of them, like the first, are keeled, and developed as *ectostoses;* unlike the "pro-osteon," the three "meso-sternal" bones (fig. 5) are much narrower than the præ-sternal segments.

There is no xiphisternum; but this evidently arises from the fact, that the seventh sternal rib has in it the substance of the xiphisternal horns, segmented altogether from the fourth "pleurosteon," and without the longitudinal cleft, which should free it from the rib. The first sternal rib (s. r.) is only partially ossified by endostosis, the rest are invested with ectosteal sheaths, as in Birds; but there is between each sternal and vertebral rib (v. r.) an intermediate tract (i. r.) which is only partially ossified by endostosis; this answers to the "costa intermedia" of the Reptile.[1] A very clean cleft separates the sternal bones, and there is, I am satisfied, a synovial cavity between them; fig. 7 shows this in a diagrammatic form; and fig. 9 the cartilaginous surface of one of the ends (magnified three diameters); fig. 8 shows the cartilage-cells (200 diameters).

In *Echidna histrix,* the scapula (fig. 11, sc.) is higher, and less decurved; there is a distinct supra-scapular endosteal bone (s. sc.) on the rounded posterior margin of the upper cartilage; the meso-scapular process (acromion, m. sc.) is larger, and more forthstanding; there is a small,

[1] I am not acquainted with a single case in which any Mammal higher than the Monotremes has ectosteal sternal ribs *originally;* this is, therefore, a true *ornithic* character; for all Birds, except the Penguin, show it.

distinct crest on the post-scapula (sc. c.); the notch between the meso- and the post-scapula is sharp and deep, and the thick base of the scapula is seen to form about one fourth of the glenoid cavity (gl.). This cavity is much larger than in *Ornithorhynchus;* the part of the coracoid (cr.) forming this is higher and thicker; and the rest of the bone is much more solid and tuberous: in its clubbed posterior angle there is an endosteal "post-epicoracoid" (p. e. cr.). The epicoracoid proper (e. cr.) is less than in the other type, and *the right* overlaps *the left:* all the bones forming the Shoulder-girdle moiety are seen to be mere osseous regions of one common cartilaginous mass. The clavicles (fig. 11, cl.), and the inter-clavicles (i. cl.), are seen to be turned upwards to a greater degree than in the *Platypus,* and the pointed lower ends of the former lie further backwards on the median splint; this keystone piece has its rami larger and its body smaller than in the other kind. The sternal piece found in the interior half of the manubrium ("præ-sternum") is, in this case, an ectosteal patch, and such an investment is also seen on the first (s. r. 1), as well as in the other sternal ribs. Fig. 10 (which is from a very young individual, and magnified one and a half diameter) shows all the ectosteal patches, save the pro-osteon; this is seen in the adult (figs. 11—13, pr. o.). The lunate ectosteal "pleurostea" are very symmetrical in the young (fig. 10, pl. o.); but in the large specimens they become very irregular (figs. 12, 13, pl. o.). Fig. 14 shows the synovial facet of the front of the third meso-sternal piece in an individual one-third adult, and also the synovial cavities between it and the sternal ribs. In fig. 10 is seen the thin laminar character of the clavicles (cl.), even at their upper ends; this shows that they are *simple*—as in the Reptiles. In the development of an endosteal "costa intermedia," in the absence of a free xiphisternum, and in the huge size of the hinder, free sternal ribs, the *Echidna* agrees very closely with the *Ornithorhynchus.* I may remark, in passing, that developmentally there is no absolute necessity for the existence of such a Class as that formed by the Birds, for the Monotremes form a very easy stepping-stone from the Reptiles to the Mammals, which are, indeed, the true culminating forms that arise, as it were, from the scaly quadrupeds. As for the Birds, I shall be able to show, in other papers, that in the most important morphological regions, namely, the skull and the face, they repeat with minute accuracy many of the characters of the Osseous Fishes.

GENERAL REMARKS ON ALL THE MAMMALIAN ORDERS ABOVE THE MONOTREMATA.

Having described the structures of the Shoulder and lower half of the thorax—showing the primordial distinctness of these regions, and their correlation in the Ovipara, and in the almost Oviparous Monotrematous Mammals, I shall now show the advanced morphological condition of the highest Vertebrate types—the frequent lessening of the masses of skeletal substance, combined with a higher metamorphic grade. This had already begun to show itself in the Birds; but is much more perfect in the Mammalia.[1] In the Marsupials, and in the rest of the Mammalia, the Shoulder-plate is aborted below; the scapula has a more or less developed supra-scapular margin, either remaining soft, or being feebly ossified by one or more endosteal patches, or by the creeping upwards of such deposit from within the main bone. The præ-scapular margin is largely developed as a rule; and sometimes it is developed as a separate cartilage, for instance, in *Carnivora.* The meso-scapula is produced outwards as a *keel,* and is often developed downwards as a free acromion process: when a clavicle is developed, there is a " meso-scapular segment"[2] of cartilage cloven from this free process, which becomes variously metamorphosed in particular types. The " præ-coracoid " is always distal, and is always present when there is a clavicle ; and to this it is variably correlated; generally, it undergoes a curious *moniliform* segmentation, the proximal part keeping in contact with the clavicle, and the distal—the counterpart of the moieties of the " omosternum " of the Tadpole—becoming correlated to the anterior half of the " præ-sternum." Behind these rudiments, a small distal epicoracoid often appears; but there are only two instances (for example, in the Mole, a near congener of the Monotreme, and in Man) in which the coracoid mass has been seen to run through from the scapula to the Sternum. There is never any " inter-clavicle," as far as I know, so that the " episternum " of the Lizard is not represented; but, as I have just shown, the so-called " episternum " of the Frog is very common;—these are two very different things! The Sternum is greatly subdivided, serially, in most cases, and the " pleurostea " are either single or symmetrical, and are separated by unchanged cartilage without clefts; by interposed fibre; or by synovial cavities. The ossification is either ectosteal or endosteal; in the latter cases it often runs rapidly into both kinds afterwards, so that the ossification becomes perfect. There is sometimes a " pro-osteon " in front of the keystone of the first costal arch; this may be ectosteal or endosteal; single or

[1] It will be seen that my descriptions of the Birds are much more *condensed* than those that relate to the Cold-blooded types; this is a necessity, because of my limited space. After having described the main modifications in the Mammalian types, I shall treat the copious Plates illustrating the various Orders as though they formed an "Atlas"; simply describing them as tersely as possible, and referring the reader to the introductory remarks now to be made.

[2] This cartilaginous nucleus, although segmented from the meso-scapula, is in reality the commencement of the præ-coracoid band, and answers to the " meso-scapular segment" and " proximal præ-coracoid" of the Bird, before segmentation has taken place.

double. The xiphi-sternum is free, and single, except in *Manis* (some species), but often shows signs of its symmetrical origin; there may be more than one (serial) "metosteon," but there is no differentiation of the "ento-sternum" (save in a trifling degree, in some Bats), and, therefore, there is no "lophosteon" except when the manubrial keel has an epiphysis, as in some Armadillos; and no "urosteon." The vertebral ribs are variously connected with the sternal,—by continuous cartilage; by intercalation of fibrous tracts; or by synovial joints; and there is not unfrequently an "intermediate rib." The sternal ribs, however solid in the adult, are always ossified *endosteally* at first.

Ordo—" MARSUPIALIA."

Examples.—Didelphys, Dasyurus, Phalangista, Halmaturus, Bettongia, Petrogale, Phascolarctos, Phascolomys.[1]

The scapula is, essentially, very uniform in all the Marsupials (see Plates XIX, XX, excluding fig. 17 in Plate XIX); the supra-scapular region (s. sc.) is very narrow, and little liable to ossification, but the body of the scapula is large and outspread; it is divisible into three regions (which are true morphological territories),—namely, the scapula proper or post-scapula, the meso-scapula, and the præ-scapula. If a line be drawn in front of the crest, from the narrowest part of the neck of the scapula to the upper outspread end of the crest, it will give the præ-scapular region: the crest itself, with the "acromion process," and the tract of bone out of which the crest rises, is the "meso-scapula;" all behind that is the scapula proper or "post-scapula." The præ-scapula is well shown in the Marsupials (see Plate XIX, figs. 1, 8, and 13, and Plate XX, figs. 3, 5, 8, and 11, p. sc.); in all it projects forwards, forming an obtuse angle; and below, is separated from the coracoid rudiment by the "supra-scapular notch,"[2]—a true morphological notch; whilst above, it melts insensibly into the "meso-scapula." The præ-scapula has the greatest vertical extent in *Didelphys* (Plate XIX, fig. 1), forms the acutest angle in the Wombat (Plate XIX, fig. 13), and is least developed in *Bettongia* (Plate XX, fig. 8). The "meso-scapula" forms a large crest in all; this is most outspread in *Didelphys*, where it, exceptionally, sends forwards a bilobate acromion; in the others, the acromion (ac.) is falcate: in all, the extremity continues soft, even to adult age. In none is there any cleft separating the meso-scapula from the scapula or præ-scapula; but the notch separating the acromion from the base of the scapula is rounded and deep (see in the Wombat, Plate XIX, fig. 16). There is no free crest on the post-scapula, dividing the "infra-spinous fossa" into two valleys; but the hinder edge of the base is thick. The coracoid (cr.) is small in all; it has a somewhat hooked form, and is thick at the base; its ossification is by a separate endosteal patch (see *Didelphys*, Plate XIX, fig. 1, and *Phalangista*, fig. 8, cr.). The clavicle (cl.) is present in all these examples;

[1] The *Didelphys*, the Dasyure, and the Koala were adult; the Phalanger was a young male, measuring eight inches from snout to root of tail (the two points from which I measure all *land* Mammals); the larger specimen of *Halmaturus Bennettii* measured 10 in. 4 l.; the smaller, 3 in. 2 l.; *Petrogale xanthopus*, 3 in. 1 l.; *Bettongia Grayi*, 2 in. 6 l.; and the Wombat, 11 in.

[2] This is the anthropotomical term; "coraco-scapular notch" would be more correct.

it is a moderately strong, *f*-shaped bar, and is weakest in *Halmaturus* (Plate XX, figs. 3 and 5, cl.), and strongest in the *Koala* (Plate XIX, fig. 11, cl.). It is never *simple*, but always has a "meso-scapular segment" (m. sc. s.) at its proximal end, and a "distal præ-coracoid segment" (p. cr.) at its sternal end. I have never seen these ossified separately in the Marsupials, and they always continue soft at the part furthest from their clavicular attachment. In most of the genera the proximal end of this compound clavicle is attached to the acromion by a rather long ligament; but in *Phascolomys* there is a small synovial cavity (sy.) formed at this part (see Plate XIX, figs. 13, 15, 16, acr., m. sc. s.). A ligament is seen passing from the rudiment of the head of the coracoid to the clavicle: this has no cartilage in it; it represents, in an abortive manner, the upper coracoid segment of the Bird: did it contain hyaline cartilage, it would form a shoulder to the clavicle, as the meso-scapular segment forms a head. But there is another element of the true Shoulder-girdle to be described,—namely, the "omosternum,"[1] and this attains its highest development in *Didelphys*, and dies out in the Phytophagous genera. I have already described the formation of the mesial parts of the Shoulder-girdle in the Batrachia (*Rana*, &c.); here they crop up again, but seldom coalesce at the mid-line, as in the Frog. These cartilages (Plate XIX, figs. 1, 2, and 3, o. st.) were, originally, continuous with the "distal præ-coracoid," but became cut off by an obliquely transverse cleft, which becomes a small synovial cavity (fig. 3, sy.); at the other end, the "omosternal moieties" are attached to the unossified extremity of the præ-sternum.[2] Figs. 2 and 3 show these parts in the Opossum (two diameters); in fig. 2, from below, and in fig. 3, in a transversely vertical section; they are *compressed* towards the Sternum, and *depressed* where they underlie the clavicle (fig. 2, o. st., cl.); their proximal end is somewhat behind the distal (fig. 1). Seen from above (fig. 4), the overlapping part of the clavicle is shown to be dilated, and capped with the unossified part of the præ-coracoid (p. cr.), the broad omosternum (o. st.) passing beneath these parts in an oblique manner. The "omosternum" of the Frog is the "serial homologue" of the *Marsupial* cartilages of the Salamandrine Amphibia; and the *Marsupial* bones of the Monotremes and "Marsupialia" are ossifications of cartilages which become segmented off from the forth-growing (pedate) lower margin of the pubic cartilages, and are serially homologous with the cartilages that become detached by a transverse cleft from the "præ-coracoid" bar—the serial homologue of the pubis. In the *Dasyure* (Plate XX, fig. 1, o. st.) the "omosternals" agree with those of the *Didelphys*; but in the Phalanger (see Plate XIX, fig. 8, two diameters, and fig. 9, three diameters) they are much smaller, and are best seen from below (fig. 9, o. st.); they are

[1] On the so-called "episternals" of the Mammalia, see an excellent paper by C. Gegenbauer, in the 'Jenaische Zeitschrift für Medicin,' &c., vol. i (1864), p. 175 et seq., and excellently translated by my friend Mr. Power for the 'Nat. Hist. Rev.,' Oct., 1865, p. 545—567. Partly in *observation*, and more in *interpretation*, I differ from M. Gegenbauer; nevertheless, I highly value his paper which came to me (as a loan from Professor Huxley) most opportunely when I was working out these parts in Oviparous Vertebrata.

[2] The figure and description of these parts given by M. Gegenbauer (see 'Nat. Hist. Rev.,' 1865, p. 546, fig. 1, ep. cl.) are wrong; the author missed the very distinct fibrous tract which separates the middle bar ("præ-sternum") from the recurved arms ("omosternum"). This confusion of parts of the true Sternum with the elements of the out-lying Shoulder-girdle has vitiated the interpretations of a large host of anatomists; through this "fault in the first concoction" we have got our most vicious theories on the nature of the limb-arch.

pyriform, and have their bulbous end directed backwards and inwards. In the herbivorous genera these parts do not chondrify (see Plate XIX, figs. 13, 14, which show those of the *Wombat,* magnified one and two diameters; Plate XIX, fig. 11, shows these parts in the *Koala,* nat. size; whilst those of the Macropidæ are displayed in Plate XX). Very young specimens show a thin film of hyaline cartilage investing the bulbous sternal end of the clavicle (Plate XX, fig. 6, *Halmaturus;* fig. 9, *Bettongia;* and fig. 12, *Petrogale,*—all ten diameters). The end of the clavicle (cl.) is seen through the thin præ-coracoid cap (figs. 9 and 12, p. cr.), and this is again capped with a delicate mass of fibrous stroma (o. st.) which lies on the bevelled edge of the narrow front end of the præ-sternum (p. st.). In a half-grown *Halmaturus* (Plate XX, figs. 3 and 4, one and a half and three diameters), this omosternal segment has become converted into a sterno-clavicular ligament (l.); in the *Wombat* a small synovial cavity (Plate XIX, fig. 14, l. sy.) may be seen; but the ligament is not dense enough to form a "meniscus."

The Sternum of the Marsupials is typically Mammalian; it is formed of a series of segments, which are rather oblong, but have concave sides, and these are ossified *ectosteally;* the præ-sternum and the xiphisternum are considerably modified. The former (Plates XIX, XX) is broad where it joins the first sternal ribs, from which it does not always become segmented, for instance, in the Wombat (Plate XIX, fig. 14, p. st. s. r. l.), and in the *Halmaturus* (Plate XX, figs. 3, 4, 5, p. st. s. r. l.): in the young *Petrogale* (Plate XX, fig. 11) a notch has appeared below, which may be completed into a transverse cleft in the adult. The anterior or coracoid region of the præ-sternum does not ossify; it is very much compressed; and what bony matter it does get comes from a forward extension of the "pleurosteon," which forms the keystone to the first thoracic arch; whilst the anterior half of the præ-sternum belongs to the same *somatome* as the seventh cervical vertebra. The sternal segments are perfect, as far as division of the cartilage is concerned, but their connection is fibrous (Plate XIX, fig. 7), for no synovial cavity appears between them; the first transverse cleft is the widest (see Plate XX, fig. 3), and is the first to appear. The main "pleurosteon" is supplemented in old age by a pair of epiphyses at each end (Plate XX, fig. 1): these are apt to fuse together (Plate XIX, fig. 1): five "pleurostea" to each sternal segment is common to the Marsupials and to many of the Rodents. There are, as a rule, four meso-sternal segments, the last of these in the Wombat (Plate XIX, fig. 13) belonging to two pairs of ribs. The xiphisternum is like a cheese-knife, and the haft is ossified by ectostosis, whilst the semicircular and often eared blade has one (Plate XIX, fig. 12—the Koala) endosteal patch, or two, as in the Dasyure (Plate XX, fig. 2). In the young *Halmaturus* the broad part is elegantly trilobate, as in the Cassowary (Plate XX, fig. 5, x); in *Didelphys* (Plate I, fig. 1, x. s. f.), and in the Koala (Plate XIX, fig. 12, x. s. f.), there is a primordial fenestra or "fontanelle." The sternal ribs (s. r.) are never segmented from the vertebral portion (v. r.), but slowly develope bony matter within, by endostosis (Plate XIX, figs. 1 and 8); there is no differentiation of the "costa intermedia;" and lastly, each sternal rib is articulated by a synovial joint to its own sternal bar and to the one in front, just as the capitulum of the vertebral rib articulates with the corresponding, and with the preceding centrum.

Order—" EDENTATA."

Examples.—A. " PHYLLOPHAGA." *Bradypus*,[1] *Cholœpus.*

B. " ENTOMOPHAGA."[2] *Manis, Pholidotus, Tatusia, Prionodos, Dasypus, Euphractus, Xenurus*,[3] *Orycteropus, Myrmecophaga, Tamandua, Cyclothurus.*

This is a very difficult group to characterise, for it is extremely polymorphous; very much more so than the Marsupialia. In the Sloth (Plate XXI) the scapula is very remarkable for the reversed proportions of the " supra-" and " infra-spinous fossæ," the latter being the smallest on account of the great relative development of the præ-scapular region (p. sc.). The supra-scapula (s. sc.) has scarcely any separate existence, and in old age it is entirely continuous with the rest of the bone (fig. 13, Aï; fig. 22, Unau). The meso-scapular crest (or spine) arises from but little more than the middle third of the bone (vertically): in the old Unau (fig. 22) a smaller intermuscular crest ekes it out, somewhat. In the young of both types the acromion is a very long flap of cartilage (figs. 1 and 16, ac.) connecting the meso-scapula with the hook of the arrested coracoid; whilst the præ-scapular and coracoid regions run into each other in front, a small oval fenestra (c. s. f.) partly cleaving these regions asunder. This continuity is eminently Reptilian, but the elevation of the crest is Mammalian. In the process of growth the acromion becomes less and less in the Aï (see figs. 1, 7, 10, and 13); but in the Unau, and in the extinct Phyllophaga, it retains its early condition, and this bridge over the "supra-spinatus" is very strong. The coracoid (cr.) is very large for a Mammal; and has, exceptionally, an ectosteal ossification, with an epiphysis in its free hook (figs. 10 and 11, cr.): nevertheless, this does not answer to more than the "head" of the ornithic bone, especially to that part of the coracoid in the typical Bird which sends upwards a strong spur, called by Professor Huxley the " clavicular process," but which does not become free and outstanding either here or in the Struthious Birds and the Reptiles. The clavicle is small in the Aï, and it has not appeared at the time of birth; both it and the correlated cartilages are best studied in half-grown specimens (figs. 10 and 11). Attached to the blunt hook of the coracoid is the meso-scapular segment (m. sc. s.), for the acromion has retired, and this is somewhat ossified by the clavicle (cl.); and at the other end of the clavicle there is a præ-coracoid segment, also partly ossified by the clavicle: beyond this is

[1] I am not aware to what species of Aï the various specimens belonged that I have examined and dissected. The youngest was an almost ripe embryo, the gift of Mr. Mivart; the figures of it are in Pl. XXI, figs. 1—6; fig. 7 is from a one-third-grown individual (Hunt. Mus.); figs. 8 and 9 another, about the same age (Hunt. Mus.); figs. 10 and 11, half-grown (Brit. Mus.); fig. 12, almost adult (Brit. Mus.); figs. 13—15, very old (Hunt. Mus.). The specimens in the Hunterian Museum belong, according to Mr. Flower, to the group termed *Arctopithecus* by Dr. Gray (see ' Proc. Zool. Soc.,' 1849, p. 65—73; Pls. x, xi). I think it is very probable that in such a low type as this the variability may be very great; and that the two species of *Bradypus* and five of *Arctopithecus* may be diminished when our knowledge is increased.

[2] See Gray, ' Proc. Zool. Soc.,' 1865, p. 359—386.

[3] Dugès, in his work on the Batrachians, refers to the Sternum of the Kabassou (*Xenurus unicinctus*, Linn., see the Translation, above, p. 86, where the word is wrongly spelt *Kabasson*); I may again refer to that extract, to show how completely the best anatomists have confounded together dermal and endo-skeletal parts.

the small pupiform omosternal piece, evidently composed of hyaline cartilage. A ligament connects the omosternum with the side of the præ-sternum (p. st.). In the old Aï (Hunt. Mus., No. 2367) the clavicle has dwindled to a small hook, capped with cartilage; and in default of the acromial connection, it articulates with the coracoid (fig. 14, cl.), whilst the structures at its distal end have degenerated into ligamentous substance. The Sternum in the nearly ripe embryo (fig. 4, from below, two and a half diameters, and figs. 5 and 6, from above, four diameters) is broad above, and very narrow in the remaining part; the præ-sternum (p. st.) is completely segmented from the meso-sternum (m. st.); it is only gently rounded in front, but does not project into the cervical region; it is not in the least segmented from the first costal arch; and the ectosteal substance of the first pair of vertebral ribs have grown down close upon it. The fore-edge of the meso-sternum is turned down below (fig. 4), and it is somewhat compressed in its narrow part, as are also all the other sternal segments: above (fig. 6) they are somewhat flattened. The sternal ribs are not ossified, nor are they segmented from the ossifying vertebral ribs; they articulate, by a cavity-joint with their own and with the preceding segment. There are only six meso-sternal pieces in this specimen; and the last piece is an aborted xiphisternum (x. st.), the keystone of the eighth costal arch. In a half-grown Aï (fig. 10) a large endosteal patch has appeared in the præ-sternum (p. st.), and one on each side of it (s. r. 1); these last are the first sternal ribs, connate, as cartilage with the vertebral portion (v. r.), and with the Sternum. In another half-grown Aï a section of the Sternum (fig. 8) shows nine pieces, and the præ-sternal centre is here seen to lie *within* the cartilage, see fig. 9, p. st., pl. o. 1; the next centre has reached the upper surface of the cartilage (pl. o. 2): between the segments there is a synovial cavity (sy.). I have seen no supernumerary bony centres in any Sternum of the Aï; fig. 12 shows the seventh, eighth, and ninth sternals of the nearly adult individual; and here may be seen the abortion of the last or xiphoid piece. In the old Aï (fig. 15), whose scapula is shown in figs. 13 and 14, there are two curious irregularities, for the præ-sternum is divided into an anterior large piece, and a very small posterior segment: here the front segment should be the "pro-osteon" (pr. o.), and the other the first "pleurosteon" (pl. o. 1). The cervical beak is more projecting; the right sternal rib is partly segmented off by a fenestra (f.), and the left by a notch (n.); and the primary continuous condition is again shown by the anchylosis of all the first arch (s. r. 1 and v. r. 1), and by the coalescence of the vertebral with the sternal ribs (v. r. 5, s. r. 5), in the next four arches. In the Unau the clavicle is larger (figs. 16 and 17—young, figs. 22 and 23—old); and the "omosternum" is composed of fibro-cartilage (figs. 17 and 19, o. st.): this part nearly reaches the manubrium in the young, but in the adult the fibro-cartilaginous segment has deteriorated into a mere ligament. The cervical part of the præ-sternum is long and emarginate in the Unau (figs. 16 and 23); it is more carinate below, and in the old specimen (fig. 23) the second pair of sternal ribs have lost their connection with their own segment, and altogether articulate with the manubrium. In fig. 16 the sternal joints are shown as a horizontal section, the flattish upper surface being sliced away, and thus the very great distinctness of the segments is better shown, reminding the observer of the "metasternals" of the Chamæleon, and of *Polychrus*. There are twelve of these altogether, and the last (s. 12) is so completely surrounded by the thirteenth sternal ribs, that it can scarcely be called a "xiphisternum." There is no segmentation of the rib itself; and in old age the *nine* foremost costal arches suffer anchylosis of the vertebral with the sternal parts.

In the Pangolins (Plate XXII, figs. 1, 2, 8, 9, 13) the scapula is broad, and the anterior margin passes gently into the superior, as in the *Platypus*, but to a less degree. The supra-scapula (s. sc.) is a moderately broad headland of persistent cartilage; the præ-scapula (p. sc.) is broader than the post-scapula (sc.), at least in *Pholidotus*, and especially in the young (fig. 8); but the post-scapula is the longest, for it is curved backwards in a falcate manner. The præ-scapula (p. sc.) is separated from the coracoid (cr.) by a small—and in the young, shallow—notch, and the ectosteal plate is a long while before it covers the lower angle of this region (fig. 8, p. sc.). There is therefore no "fenestra," such as we see in the Sloth, but the "coraco-scapular notch" is typically Mammalian. In the young (fig. 8, m. sc.) there is no "acromion process" to the meso-scapula, but this part has a vertical front margin (fig. 9): in the adult, in both types, the periosteal growths form a small rudiment of this process (figs. 1, 2, 13, ac.). The Pangolins are unique in possessing a true cleft, which partially separates the meso-scapula from the rest of the blade-bone; in *Manis* this cleft is seen as a fenestra (fig. 13, f.) dividing, in some degree, the "post-" from the "meso-scapula;" but in *Pholidotus* (figs. 2, 8, 9, f.) the cleavage takes place in the root of the spine; and thus, if perfect, would cut off the crest as a free "meso-scapular ray." In the old *Pholidotus* (fig. 2) this fenestra is much diminished by means of overgrowing layers of bone. In the old specimens (figs. 1 and 13, sc.) the posterior edge of the scapula is much thickened. The coracoid (figs. 1, 2, 13, cr.) is in its last stage of abortion; being the merest convexity, and having in it a small endosteal patch. These imbricated types have no clavicles, and the correlated cartilages are absent: the Sternum, however, is developed to an extraordinary degree.

In the young *Pholidotus* (fig. 8) the Sternum is seen to be of moderate breadth up to the last two-fifths of the xiphoid region; the first sternal ribs are already segmented from the side of the "præ-sternum" (p. st. s. r. 1); and the latter part is cut off from the "meso-sternum;" there are then two more meso-sternal clefts, then two are absent, and two more appear, the last of which passes across between the "meso-" and "xiphi-sternum" (x.). A section (fig. 10) shows the other clefts as deep and wide notches in the lower surface of the Sternum, and also the endosteal patches that occupy the first and second meso-sternal joints, and the proximal part of the xiphisternum. The two foremost are "pleurostea," and the last is a "metosteon:" the other meso-sternal regions are dotted with large vascular puncta, preparatory to ossification. Behind the metosteon (fig. 8, m. t. o.) the xiphisternal horns are separated by a fenestra or "fontanelle" (x. f.); and when they have closed upon each other again they spread out into a very large, semi-oval, sinuous, eared blade. The four foremost thoracic arches have no cleft between the vertebral (v. r.) and sternal ribs (s. r.), in those that succeed this takes place; but no cavity is formed (see fig. 11, v. r., s. r., f.), but the two elements are tied together by fibrous tissue.

In the adult *Pholidotus* (Plate XXII, figs. 1, 3, 4, 5, 6—two thirds nat. size, and three diameters) we see what changes have taken place. There is still very much unchanged cartilage; but the *endosteal* patches have grown through, vertically, so as to appear on both the upper and the lower surfaces of the segments: they are, however, arrested laterally, save in the free-edged xiphisternal bone ("metosteon" m. t. o.). All the transverse clefts have become perfect, and are in the highest degree of segmentation, having synovial joint-cavities (sy.). There are three synovial cavities, which are, as far as I have seen, unique; the first of these is in the transverse cleft between the front and hinder halves of the præ-sternum, between the "pro osteon" (pr. o.) and the first "pleurosteon" (pl. o.);[1] the other two are between the third and seventh (last)

[1] M. Gegenbauer ('Nat. Hist. Rev.,' 1865, p. 548, fig. 2, m.) describes this fibrous cleft in *Cœlogenys paca*; the foremost segment is called by him the "median episternal piece" (see also p. 209, *infrà*).

meso-sternal segments (m. st. 3, and m. st. 7): this is the more to be wondered at by the morphologist, for the right and left sternal moieties in the mid-region had quite coalesced in the young individual (see fig. 8); but we see that the primordial fissure opens again in these places, to be perfected into synovial cavities (see figs. 3 and 6, sy.) The feebly ossified sternal ribs become extremely compressed, and are of great width from below upwards, where they articulate with the sternal pieces fore and aft of them (see fig. 5, s. r., which shows the lower end of the fourth sternal ribs and the front of the double third meso-sternal): they are more than flush with the sternal segments: these latter articulate with each other by much smaller synovial facets (see figs. 4 and 5, m. st.). The joint between the vertebral and sternal ribs from the fifth arch, backwards, does not acquire a cavity (fig. 7, v. r., s. r., f. r.).

The "metosteon" only ossifies the front half of the handle of the great xiphoid blade; and the fontanelle is a persistent fissure, nearly an inch in length (fig. 1, m. t. o., x., x. f.).

In *Manis longicauda* (figs. 13—17; figs. 13, 14, and 17, two thirds nat. size; fig. 15, three diameters; and fig. 16, nearly one and a half diameters) the lower half of the thorax is much denser, in its ossification; there is neither a separate "proosteon," nor a transverse cleft in the "præsternum" (p. st.). The first meso-sternal segment is symmetrical, and has a cavity between its halves; there are behind these three azygous segments, whilst the rest of the meso-sternum is composed of two segments in a connate condition. The whole Sternum is much flattened in this type (see the inverted section, fig. 16, which shows the synovial cavities, and the gradual thickening towards the xiphisternum), and becomes very broad behind the ribs (m. t. o.): the xiphisternum bifurcates between the well-ossified first "metosteon," and grows backwards as two flat, narrow, extremely long "horns;" the left of these is eight inches eight lines long, the right nine inches six lines; the rest of the Sternum two inches two lines; the whole length, on the right side, being eleven inches eight lines. These "horns" are feebly ossified endosteally; the left ends in a free point, but the right horn is continuous at its supero-posterior end with three abdominal ribs similarly ossified. In front of the foremost of the abdominal ribs continuous with the "horn," is the first of this curious series (figs. 13 and 17, a. r. 1); it is unossified, and is fourteen lines in length. The second abdominal rib (a. r. 2) is five inches six lines long; the third (a. r. 3) five inches two lines, and the fourth (a. r. 4) four inches. The feeble endosteal substance is broken up into several patches in these abdominal ribs; the space between them and the "xiphisternal horn," from which they have never been cleft at their upper ends, is filled with a peculiar muscle, the counterpart of that which is seen to be quite symmetrical in *Pholidotus* (fig. 12, x., x. m.), which shows the under surface of xiphoid and its muscles. The first six pairs of vertebral ribs do not become segmented from the sternals in *Manis;* the rest are so segmented, and the connection is by fibrous tissue (fig. 15, f. r.). The vertebral rib (v. r.) is concave, and the head of the sternal rib (s. r.) convex: they are both flat in *Pholidotus* (fig. 11.)[1]

The Anteaters are few in number, but these are types of three very distinct Families, the Aard-vark representing one, the Little Anteater another, and the Tamanoir (Ant-bear) and the Tamandua a third. In *Orycteropus capensis,* the representative of the first of these

[1] This last sub-genus does not necessarily differ from *Manis* in the xiphisternum; for the reader may find the long free "horns" in the fine skeleton of *Pholidotus Africanus,* Gray, in the British Museum.

Families, the scapula (Plate XXIII, fig. 17, one third nat. size) is high, angular, oblique, rather broad above and narrow below; the supra-scapula (s. sc.) is a mere selvedge of cartilage; the præ-scapula (p. sc.) projects considerably forwards, and ends, halfway down, in an obtuse, rounded angle. The meso-scapula (m. sc.) is developed into a strong, straight crest, which becomes very broad, and bilobate below; this is the acromion (ac.); its "metacromial process" (m. ac.) is turned backwards and upwards, but the primary bar is in a line with the spine. The post-scapula (sc.) bulges, and then contracts, so that the scapula has a sort of second neck of moderate width. The coracoid (cr.) is a short, curved, crumpled process; it is separated from the præ-scapula by a very shallow, open notch. The clavicle (cl.) has used up its correlated cartilages; it is a strong, curved club, being narrow and rounded above, and very swollen where it articulates with the manubrium. This latter part (fig. 18, p. st.) is trowel-shaped, the first sternals articulating with the "handle;" the rest of the joints are one third the width of the clavicular part of the præ-sternum; they are very uniform, oblong, flat (see fig. 19), the lower surface being of less extent than the upper; they are thoroughly ossified, have no additional ossicles, at least none in old age, and articulate by a fibrous septum which seems to possess no cavity. The xiphisternum (fig. 20, x.) spreads but little at the end, and has a small unossified margin. The vertebral ribs (v. r.) are not segmented from the sternals (s. r.), and these latter are partially ossified endosteally: there is no "costa intermedia."

In *Cyclothurus didactylus*, which represents the next Family (Plate XXII, figs. 18—20, one and a half diameter; fig. 21, six diameters; and fig. 22, three diameters) the scapula, like the rest of the skeleton, is much more densely ossified than in the Aard-vark, and the supra-scapular region (fig. 18, s. sc.) is completely ossified continuously with the rest of the bone. The whole blade is broader, the præ-scapula (p. sc.) reaching lower down, and ending in an acute angle; thus the "notch" is more clearly defined. The spine (m. sc.) is thick, bulges backwards, and is continuous with the coracoid, distally, so that there is no notch between it and the neck of the bone. The post-scapula (sc.) projects considerably behind, and a second crest arises from it sub-marginally; the coracoid (cr.) is but ill-defined, and is small; the acromion (ac.), which overrides it, is oblong and rounded. The clavicle (cl.) is of moderate size, and is gently curved; it has but little cartilage (m. sc. s.) above, but more below (fig. 21, p. cr.); and the omosternum (o. st.) has a large bony nucleus in it above, and below forms a sort of second, pedate segment. The lower part of the thorax is intensely ossified; and there is no sign, in the adult, of subsidiary osseous centres. The Sternum (fig. 18) is segmented in front, after the fashion described in the old Aï (Plate XXI, fig. 15), for the manubrium has a small hinder segment, which helps to carry the second costal arch, and a large trilobate segment in front, which is in relation to the "omosternum," besides articulating with the first costal arch; this arch does not divide into a sternal and a vertebral portion (Plate XXI fig. 18, p. st., v. r. 1). Here the first bone is the "pro-osteon," and the second the first "pleurosteon;" there are six more of this category in the meso-sternum; and a long, stout, styliform xiphoid (x.), which is somewhat oval in section, has a well-finished, long "metosteon," and a small terminal arrested bony centre. From what I have seen in embryo Armadilloes, I have no doubt concerning the endosteal character of the sternal pieces and sternal ribs in their early condition.

Each sternal segment appears to have been perfectly cleft from its successor, so as to form a synovial cavity; and a cavity exists between the vertebral and sternal ribs (fig. 22, s. r., v. r., sy.). The sternal pieces are high (see fig. 20), compressed below (fig. 19), and rounded above (fig. 18); the sternal ribs articulate with them by an oval condyle, these segments being compressed below (fig. 20). The vertebral ribs (figs. 18—20, v. r.) form the most exquisite jointed armour; each rib sending backwards a thick, strong flap, which overlaps the succeeding bar: this *continuous* plate is homologous to the *segmented* plate which grows from the Bird's rib; but it has a much greater vertical development.[1]

The Ant-bear and Tamandua are remnants of the third Family of this division of the Edentata; the scapula (Plate XXIII, fig. 21, *Myrmecophaga jubata*, one-third natural size) would be, if its base were cut away, a very even semi-oval in form; for there is no *angle* between the supra-scapular and præ-scapular margins, and the latter is continuous with front of the large coracoid. All along this supero-anterior edge there is a headland of soft cartilage (s. sc., p. sc., cr.); and a tract of cartilage separates the coracoid from the præ-scapula; and these two regions are also more clearly mapped out by the large, oval, coraco-scapular fenestra" (c. s. f.), as in the Sloths. The adze-shaped coracoid (cr.) has its own ectosteal sheath; this bone helps to form the glenoid cup (gl.). The area of the "supra-spinous fossa" is about equal to that of the "infra-spinous;" the meso-scapular "spine" is moderate in height and thickness, and sends an overlapping process backwards, just below its middle; it is elegantly curved backwards in its fixed part, and then its free part, the acromion (ac.), has a semilunar form, the curve being in the opposite direction, or forwards. At its root this large acromion sends backwards a rudimentary "metacromion" (m. ac.). The post-scapular region (sc.) is nearly equally divided by a second spine, which has the same backward curve as the meso-scapular spine, and converges towards the latter, downwards. The posterior (= *inferior* of Anthropotomy) margin is elegantly arcuate, but short; behind, it has a small projection, which gives it a sinuous outline: the long sweep of the soft margin of the scapula makes this side to be as much *inferior* in the quadruped as it is in the *erect* human creature.

There are no clavicles nor clavicular correlates in the Myrmecophaginæ proper; but the Sternum is full of interest to the morphologist. The præ-sternum (Plate XXIII, fig. 22, p. st., *Tamandua bivittata*, three-quarters adult, natural size) is a thin transversely elliptical plate, which somewhat overlaps the second perfect costal arch below (s. r. 2). Its endosteal deposit has reached the surface and acquired an ectosteal layer, but the whole periphery of the plate is still soft; the ends of this narrow oval are somewhat squared, to articulate with the sternal moieties of the first thoracic arch (d. r. 1, s. r. 1). There is a Reptilian looseness as to *number* here, as in the Sloths (these types agree also as to the very reptilian coracoid and its "fenestra"); for there is an eighth cervical vertebra[2] (c. v. 8); its lower part is pointed, and free, and just touches the manubrium; it is not ossified at this stage. The meso-sternal segments take on a very remarkable character; they are short-rounded above, saddle-backed, like the "centrum" of a vertebra; and, together, imitate in an inverted manner the vertebral column of a Mammal very wonderfully, for each segment sends downwards a deep, long, clubbed process, like a vertebral spine. There is to each segment of the meso-sternum one principal "pleurosteon," evidently developed endosteally like that of the Sloth and Armadillo, but becoming very perfect afterwards; to this main piece there is the superaddition of two pairs of upper epiphyses—one pair at each end; and two pairs of much smaller centres in the unossified inferior process (Plate XXIII, figs. 24, 25, m. st., u. ep.,

[1] The appendages of the ribs are nearly parallel with the ribs themselves in *Serpentarius*: in the adult bird they become anchylosed, and then answer, very exactly, to these flaps of the Tamandua.

[2] I am not sure whether this has been noticed before.

l. ep., four diameters). Each meso-sternal segment is connected to its fellows by a synovial joint (sy.), and between each two contiguous segments there is an upper and lower synovial cavity for the sternal rib (s. r.), which has the unique character of being two-headed: thus it is curiously imitative of the vertebral rib of the higher Classes with its "capitulum" and "tuberculum." The synovial cavities for the sternal ribs are all bi-form; and in each of the semi-facets below there is a separate epiphysis: the larger, upper epiphyses are related to both the corresponding sternal joints, and also to the upper head of the sternal rib.[1]

Each sternal segment projects in front, and is emarginate behind (see fig. 24); it is also somewhat hourglass-shaped: altogether, there are *nine* "pleurosteal" centres in each meso-sternal piece. The xiphisternum (fig. 23, x.) is more flattened than in *Cyclothurus;* it is somewhat spatulate, and has in it, anteriorly, four "metostea:" in old age these become anchylosed (fig. 26). The vertebral and sternal ribs (fig. 22, v. r., s. r.) have neither intermediate piece nor cleft between them; the latter ossify very slowly by endostosis.

In the Dasypinæ, the endo-skeleton has not suffered in intensity of ossification because of its investment by a most exquisite dermal armour; but it is like what is seen in the *Lepidosteus,* which, besides its enamelled coat of mail, has an endo-skeleton stronger by far than that of ordinary Fishes.

The scapula (Plate XXIII, fig. 1, embryo of *Tatusia peba,* two and a half diameters; and fig. 12, embryo of *Euphractus villosus,* two diameters) is in one case (fig. 1), *high* and angular, like that of the Aard-vark, and in the other (fig. 10) *broad* and rounded, like that of the Ant-bear.

In *T. peba* (fig. 1, s. sc.) the supra-scapular region is well defined, and has a rather straight upper outline; its angle is rounded in front and hooked behind; the præ-scapular region (p. sc.) is an almost parallel band of bone; in front it is but little notched off from the small hooked coracoid (cr.) with its *internal* osseous centre: there is no "fenestra" in the Dasypoids. The meso-scapular spine (m. sc.) is high, thick below, and sends off a long, flat, forwardly bent acromion (ac.): this is simple in *E. villosus* (fig. 12), but has a metacromial angle in *T. peba* (fig. 1). In the adult this angle has grown into a sharp spur (fig. 2, m. ac.), and here we see that the acromion (ac.) has its own ectosteal bony centre, besides its terminal epiphysis. The post-scapula of *T. peba* is triangular (fig. 1, sc.); in *E. villosus* is much broader, and has a notable second crest (fig. 12, sc.); in both the "supra-spinous fossa" is much the smallest. In *E. villosus* (fig. 12) the "supra-" and "præ-scapular" regions, at their junction, form the projecting upper boundary of the large lunate coraco-scapular notch. The clavicle (cl.) is generally well-developed, and its correlates are perfectly normal (figs. 1 and 10, m. sc. s., p. cr., o. st.); in *T. peba* the omo-sternal moiety (o. st.) is composed of hyaline cartilage, but in *E. villosus* (fig. 13, o. st. six diameters), it is well segmented off from the præ-coracoid, but soon degenerates (before birth) into fibro-cartilage: in this species the præ-coracoid segment is of considerable length.

The coalescence of the sternal moieties and their transverse cleavage are complete before birth (Plate XXIII, figs. 1 and 12); the Sternum, as a whole, is greatly dilated both in front

[1] In figs. 24 and 25, from above and laterally, the parts are drawn in a diagrammatic manner; and the head of the sternal rib in fig. 25 is pushed *downwards;* in fig. 24 the upper heads of a pair of sternal ribs are shown attached behind a meso-sternal segment; but they *converge* too much in the figure, and lie, in reality, on a much lower plane than the upper surface of the sternal segment. (See fig. 25.)

and behind; in front the præ-sternum is narrowed and square between the clavicles in *T. peba;* in *E. villosus* it is but little produced, and is emarginate at this part. It dilates greatly between the first sternal ribs (s. r.), which are extremely broad, and articulate with the manubrium by an oblique, oblong synovial cavity. Behind the first ribs the manubrium gently lessens to two-fifths of its width to again articulate with the first meso-sternal; there are four of these (figs. 1 and 12, m. st.), which gradually lessen towards the xiphoid cartilage. This latter part (x.) is very elegant in *T. peba,* being very much like what is seen in certain Anoura; it is like a cheese-knife, but the "blade" has notched retral "ears." The sternal segments are nearly flat at the top, and contract rapidly, being sub-carinate below (fig. 14, *E. villosus,* three diameters; second meso-sternal from behind, and section of third sternal ribs); at this stage the joint-cavities are continuous. Of the two embryos, that of *E. villosus* was ripest (both nearly ripe) but in it the first pleurosteon only, had appeared (fig. 12): in the second joint the vascular puncta were seen. In *T. peba* there were three pleurostea; a section through the Sternum shows (fig. 6, plo., five diameters) that the osseous growth is internal: there is a nail-shaped "metosteon" in the xiphoid (x.). In *T. peba* there is a commenced transverse cleft between the vertebral and sternal ribs (fig. 1, v. r., s. r.); this has not yet appeared in *E. villosus;* and in that species the posterior sternal ribs are of great breadth, as in the *Echidna.* In a three-quarters-grown *T. peba* (fig. 7, one and a half diameters) the front or coracoid part of the præ-sternum is lessened, and is only partly ossified by the first pleurosteon, which also leaves its costal and posterior regions untouched: in these, however, epiphyses appear; one for each costal facet; one behind for the first meso-sternal; and one on each side for the semi-facets for the second sternal ribs. When the meso-sternals are viewed endwise (fig. 8, *T. peba,* three-quarters adult; first meso-sternal, from behind, two diameters) it is then apparent that there is an additional pleurosteon in each of the five cartilaginous facets, at each end of the segment: for the sternal ribs get a double head; each head articulates with a semi-facet of two sternal pieces; and every such cartilaginous face has an epiphysis within it. The main facet, that for the corresponding part of another sternal segment, is sub-triangular, and this has the largest epiphysis within it. Altogether, each sternal segment has in it *eleven* osseous centres! The articulation of these quasi-vertebræ is "opisthocœlian;" the last meso-sternal is sometimes bi-convex, however (see fig. 15, m. st., *Prionodos gigas,* two-thirds natural size), and the xiphoid may be altogether wider than the meso-sternals (fig. 15, x.): the outspread end of the xiphoid remains soft. In this same kind (*Prionodos*) the manubrium (fig. 16, ideal section, two-thirds natural size) is strongly keeled; and, as the bony matter of the great "pleurosteon" is slow to reach the bottom of the keel, this part is finished by a second endosteal patch, which has the most claim of any Mammalian sternal bone I have seen to be considered the counterpart of the ornithic keel-bone ("lophosteon").

It is possible that a small endosteal sternal rib may appear in the first costal arch in *E. villosus* (see fig. 12, s. r. 1); at any rate, the first vertebral rib (v. r. 1) reaches the Sternum below. In the two-thirds adult *T. peba,* such an osseous centre appears (fig. 3, s. r. 1); in the same specimen the "costa intermedia" is well shown (fig. 4, i. r., sixth right rib, nat. size); indeed, there are three centres at this part, above the synovial joint (sy.): the same rib in a very old individual (fig. 5) has lost all traces of this beautiful outcropping of a Reptilian character. A rib from the middle of the chest in *Xenurus unicinctus* (fig. 9, nat. size) shows no trace of this segment; this character, however, is variable in the same individual, as may be seen in rather old specimens of *Dasypus sexcinctus* (*Euphractus setosus*), for in the last fully developed rib but two (fig. 10, v. r.,

i. r., s. r.) I find a large intermediate rib, with a smaller supernumerary ossicle both above and below it: whilst in the one in front of it (fig. 11) there is no distinct intermediate bone: here, also, I note a curious variability, namely, in *T. peba* (fig. 4), the synovial joint (sy.) is below the "costa intermedia;" but in *D. sexcinctus* (fig. 10, sy.) it is above it.[1]

Ordo—" RODENTIA."

Examples.—Hystrix, Helamys, Bathyergus, Cavia, Dasyprocta, Arvicola, Arctomys, Mus, Lepus, Cricetus, Myoxus, Sciurus.

The Rodents are more polymorphous than the Marsupials, but less so than the Edentata. My illustrations give a great variety in this group; and in the Muridæ, Caviidæ, and Leporidæ, the development of the parts is shown. The scapula in this tribe (Plate XIX, fig. 17, and Plates XXIV—XXVI, excluding fig. 16 in Plate XXV) is generally high and narrow; having the supra-spinous fossa smaller than the "infra-spinous;" the spine moderately developed, and soon freeing itself from the neck to form a long acromion process. This latter part is generally simple, but in some genera the metacromial process attains its greatest size (Plate XXIV, figs. 1, 6, and 14; and Plate XXV, figs. 1 and 3, m. ac.). There is no scapular fenestra, and the præ-scapula seldom projects much forwards; it does so to the greatest extent in *Bathyergus* (Plate XIX, fig. 17, p. sc.), in *Arctomys* (Plate XXIV, fig. 14), and in *Cricetus* (Plate XXV, fig. 7). The supra-scapular region has but little separateness, even in ossification (see Plate XXVI, fig. 8, *Mus. minutus;* Plate XXIV, fig. 14, *Arctomys;* and Plate XIX, fig. 17, *Bathyergus*): the coracoid (cr.) is always a small, blunt hook. Although the meso-scapula of the Rodents is never fenestrate, yet the great depth of the " notch" between it and the neck of the scapula shows the great tendency there is to the cleavage of this part from the rest of the blade-bone, for the correlation of the meso-scapula to the thick muscular masses, fore and aft of it, differentiates it as much from the rest of the scapula as the " ento-sternal" of the Bird from the lateral regions, and from the same cause. The clavicle (cl.) is seldom altogether absent in the Rodents, and the correlated cartilages suffer most degradation when it is largest, as in the Sciuridæ (Plate XXV, figs. 8—9, *Myoxus avellanarius*, figs. 12—15, *Sciurus palmarum;* and in the Beaver). Answering to the anterior fork of the Shoulder-girdle moiety of the Frog, we have an interrupted moniliform structure, and as many as four of these cartilaginous bead-like segments appear on each side in many species. Besides these, there is very often another cartilaginous rudiment on each side answering to a part of the base of the hinder fork in the Frog, for instance, the epicoracoid. In the Guinea-pig (Plate XXIV, figs. 1—7), the order of the appearance of these parts is very curious. Nearly ripe embryos show no clavicle, meso-scapular segment, nor præ-coracoid; their tissue is at that time amorphous; but the "omosternum" (figs. 1—3 o. st.) is apparent as a pair of small ovoidal segments of soft cartilage on each side above the free end of the præ-sternum (p. st.). Below, on the front of the bony sheath of the first vertebral

[1] I must remark in the Order Edentata its extreme richness of morphological variety, the interchangeable characters throwing light upon their relationships *inter se*, and also below and above them in the Vertebrate Sub-kingdom: the morphology of the skulls, well worked out in many stages, would yield the most valuable results.

rib (v. r. 1) there is a small tongue of hyaline cartilage (figs. 4 and 5, e. cr., fourteen diameters): this is the epicoracoid; it has already coalesced with the cartilage of the rib. In a Guinea-pig a month old (figs. 6 and 7, one and one-third, and four diameters) there is a small clavicle (cl.), a truncated, oval "meso-scapular" segment, and a "præ-coracoid," all near together, but far from the acromion (ac.), and from the "omosternum" (o. st.). By this time the four omosternal "beads" have coalesced into a small heart-shaped plate (fig. 6, o. st.): the epicoracoid, also (fig. 6, e. cr.), has become ossified by a centre of its own. In *Arvicola agrestis* (nearly ripe) the "meso-scapular segment" above the clavicle is small; below (Plate XXIV, fig. 9, cl. p. cr. o. st.), the præ-coracoid has a pair of segments lying sternad of it; these are the omosternum (o. st.). At this time there is a spindle-shaped epi-coracoid (e. cr.) in the *axil* of the first sternal rib; it is composed of soft cartilage. In a few days after birth the lowest segment of the omosternum has become converted into ligamentous tissue, and the "meso-scapular" segment has been converted into bone by the upper end of the clavicle (Plate XXIV, fig. 10, cl.). The clavicle is yielding bony substance to the præ-coracoid; the omosternum (o. st.) is elongating; and the soft epicoracoids are converted into a delicate bony spindle (fig. 12, e. cr.).

In the Domestic Mouse (nearly ripe) the beaded cartilages can all be seen (Plate XXVI, fig. 1, m. sc. s., p. cr., o. st.), and also the fusiform epicoracoid, like a bud in the axil of the first rib (e. cr., s. r. 1). In the adult Mouse (figs. 2 and 3, o. st.), if I mistake not, the two omosternal moieties have coalesced, contrary to what takes place in *Arvicola*, but not contrary to what takes place to a greater extent in *Cavia*. It is seen that these omosternals are very bulbous below, not pointed as in the embryo: in this part there is an endosteal bone. The meso-scapular segment (fig. 4, m. sc. s.) and the præ-coracoid (fig. 2, p. cr.) resist the ossifying action of the clavicle (cl.) in the adult; but the epicoracoids (figs. 2 and 3, e. cr.) soon become solid bone; they are oval, and thickened in the middle. The præ-coracoid and meso-scapular segment have a very similar development in the other species of the genus *Mus* (see figs. 5 and 6—*M. sylvaticus*, half-grown; figs. 8 and 9—*M. minutus*, old; and figs. 10, 11, 12—*M. decumanus*, in three stages); but the omosternal segment never subdivides in *M. decumanus;* it is pointed below, and becomes ossified to a greater extent (fig. 12, o. st.). That ossicle has not appeared in the half-grown Wood-mouse (fig. 5, o. st.), but in the old Harvest-mouse (figs. 8 and 9, o. st.) there are two osseous centres in each of the tear-shaped cartilages; the lower answers to that in *M. musculus;* and the upper, which is unique, is curiously hooked. M. Gegenbauer noticed this additional bone ('Nat. Hist. Rev.,' Oct., 1865, p. 551). In *M. sylvaticus* and *M. minutus* the epicoracoid (figs. 5, 6, 8, and 9, e. cr.) are thin, triangular, notched bones; in *M. decumanus*, two or three days before birth, there is a small granule of soft cartilage in the costal axil (fig. 10, e. cr.); in two or three days after birth it has become more dense, and is lanceolate (fig. 11, e. cr.); in the two-thirds grown specimen (fig. 12) it has no separate existence, although there is a small epiphysis (ep.) in the manubrial cartilage (p. st.) where it once existed.

In the Porcupine there is a great development of these parts; in *Hystrix cristata*, apparently full-grown (Plate XX, figs. 15, 16, nat. size), the meso-scapular segment is a large ovoidal flap (m. sc. s.), scarcely affected by the clavicle (cl.); the præ-coracoid (p. cr.) has its own internal centre; and the long, stout omosternals (o. st.), cupped above and rounded below, are not ossified.[1] In

[1] I have very little doubt of the existence of a continuous band of soft, large-celled cartilage in the embryo of the Porcupine; even in the adult the intercalated clavicle has had very little influence upon the cartilaginous segments.

an immature specimen of *H. alophus* (Hunt. Mus., No. 2113) the meso-scapular segment (fig. 14, m. sc. s.) has become articular cartilage to the small clavicle (cl.); the rounded præ-coracoid (p. cr.) ossifies independently; and each omosternal (o. st.) is a long, rib-like ray, with an osseous centre for its pith. In *Bathyergus maritimus* (Hunt. Mus., Nos. 2246, 2247) the meso-scapular segment (Plate XIX, figs. 17, 18, m. sc. s.) is a considerable, carpiform bone, quite independent of the clavicle (cl.), as also is the broad, rounded præ-coracoid (p. cr.). In this type the omosternum has been reduced to a ligamentous condition; as it is also in the Beaver, and in the next example. In *Helamys capensis* (Plate XIX, fig. 19) the meso-scapular segment is used up by the clavicle (cl.), but the præ-coracoid (p. cr.) is a solid, self-ossified mass. In the tame Rabbit, the clavicle and the cartilages cannot be found at birth (see Plate XXV, figs. 1 and 2); in a specimen (wild) seven or eight months old, all these parts can be seen (figs. 3 and 4; natural size and two diameters); the meso-scapular segment (m. sc. s.) is semi-oval, and quite free of the feeble clavicle (cl.); the præ-coracoid (p. cr.) is small, and attached to the distal end of the clavicle; and cleanly cleft from this is the long, nail-like omosternum (o. st.): the whole chain of structures only takes up half the distance between the acromion and the præ-sternum (ac. p. st.). In *Arctomys ludovicianus* (Plate XXIV, figs. 14—16; natural size and three diameters), the meso-scapular segment, in the adult, merely forms a film of cartilage over the upper end of the clavicle. The other end is made clavate by the addition of the præ-coracoid (p. cr.), which has, however, its own osseous centre. The seed-like omosternals have their own internal centre (o. st.), and at each end of these there is a small joint-cavity (fig. 16.) In *Cricetus vulgaris* (Plate XXV, figs. 6 and 7; one-and-a-half and three diameters), the meso-scapular and præ-coracoid segments (m. sc. s., p. cr.) form a cap to the ends of the clavicle (cl.); the omosternal segment (o. st.) continues soft, at least for a long period. The clavicle uses the meso-scapular segment and the præ-coracoid as articular cartilage in *Myoxus* (Plate XXV, figs. 8 and 9); and also in *Sciurus palmarum* (figs. 13 and 15). In these Sciurine types the omosternals (o. st.) are mere meniscoid fibro-cartilages, of a triangular form, and imbedded in the sterno-clavicular ligaments (see figs. 9 and 13, o. st.).

The Sternum in the Rodentia agrees very much with the same part in the Marsupials; the segmentation is, however, less complete; but the principal bones are *ectosteal*. Except in the lowest types (*e.g. Cavia, Lepus*), the manubrium is broad; and in many instances the *cervical* part of this division of the sternum is but little produced.[1]

The transverse cleavage of the general sternal bar takes place to a less extent than in the Marsupials; and when it is completest, for instance, in *Arctomys* (Plate XXIV, fig. 14) and *Mus* (Plate XXVI, figs. 5, 8, and 12) there is no joint-cavity, that I can discover. In *Helamys* (Plate XIX, fig. 19) the cartilaginous mass between the shafts is only notched below, and ultimately it becomes converted into an epiphysis belonging to the shaft fore and aft of it. Such an azygous epiphysis can be seen in *Mus decumanus* (Plate XXVI, fig. 13, ep.), even when the segmentation is more perfect, a small grain of cartilage being left in the fissure. In the new-born Rabbit, the manubrium has become nearly cut off (Plate XXV, figs. 1, 2, p. st.); but this fills in again. Afterwards an azygous epiphysis appears in the interspaces of the meso-sternal region (Plate XXV,

[1] It is this part of the Sternum which M. Gegenbauer supposes to belong to the Shoulder-girdle, —as the "median episternum," in *Cœlogenys*; it is described as being segmented off by fibrous tissue ('Nat. Hist. Rev.,' 1865, p. 548, fig. 2 m.). I have already shown that this part is separated from the *costal half of the præ-sternum* by a synovial joint in *Pholidotus Dalmannii* (Pl. XXII, fig. 1, pr. o.); it is merely the coalesced tips of the front sternal horns.

figs. 3, ep.). In many Rodents, when the transverse cleft either quite (*Arctomys*) or nearly (*Mus sylvaticus*, *Myoxus avellanarius*) cuts through the cartilage, there are two epiphyses at each end of each shaft-bone (Plate XXV, figs. 8—11; Plate XXVI, fig. 5, ep.); so that there are five pleurostea to each sternal segment. This is well shown in *Myoxus* (Plate XXV, fig. 10, ep.), and in *Cricetus* (fig. 6, ep.); these twin epiphyses are very apt to coalesce afterwards, as in *Hystrix* (Plate XX, figs. 14, 15, ep.), and in *Mus minutus* (Plate XXVI, fig. 8, ep.). The interclavicular half of the manubrium is not pointed in the young Rabbit (Plate XXV, figs. 1, 2, p. st.), but shows the remains of the primordial space between the "horns;" in the large specimen (Plate XXV, fig. 5, p. st.) this part is acute and keeled. In *Dasyprocta acouchi* (Plate XXIV, fig. 8, two diameters) this cervical part is half ossified by the manubrial shaft (pl. o. 1), and the pointed end by its own "proosteon" (pr. o.) as an epiphysis. In *Helamys* (Plate XIX, fig. 19), the broad præ-sternum is surmounted by an interclavicular plate, which is squarish, and has an ectosteal bone (pr. o.), with an epiphysis in front of it, and one intervening between it and the first "pleurosteon" (pl. o. 1): there has been some transverse segmentation here, perhaps perfect, such as M. Gegenbauer describes in the *Cœlogenys* (see note, p. 209).

In *Cavia aperea*, a month old (Plate XXIV, fig. 6, pr. o.), a squarish ectosteal plate appears in front of the first sternal rib, on the base of the long interclavicular sternal plate. At this stage there is no segmentation between the "proosteon" and the first "pleurosteon" (pl. o. 1), although a very good fissure has appeared between the manubrium and the first meso-sternal piece (m. st. 1). M. Gegenbauer (*op. cit.* p. 549) confounds the "proosteon" of the Cavy with the episternal series; a mistake which vitiates all his reasoning. The development of the sternal ossifications is by symmetrical "pleurostea" and "metostea" in *Mus musculus* (Plate XXVI, fig. 1, pl. o., m. t. o.), but in *Mus decumanus* by azygous centres (fig. 10, pl. o.); in the latter the primordial fissure (p. f.) closes much sooner than in the small species. I find azygous centres in *Lepus* (Plate XXV, figs. 1 and 2), and in *Cavia* (Plate XXIV, figs. 1, 2, and 3). The xiphoid part of the Sternum is transversely oval in *Lepus* (Platé XXV, fig. 3, x.); like a cheese-knife in *Arvicola* (Plate XXIV, fig. 10, x.), and in *Mus minutus* (Plate XXVI, fig. 8, x.); but the angles are rounded off in *Mus sylvaticus* (Plate XXVI, fig. 5, x.), and in *Cavia* (Plate XXIV, fig. 6, x.). In all kinds we find the proximal narrow part occupied by a metosteon, and in some there is another feebler (endosteal) centre in the broad cartilage (Plate XXV, fig. 3, x., and Plate XXVI, fig. 8, x.). In *Arctomys ludovicianus* there are two remnants of the primordial fissures, as fontanelles (Plate XXIV, fig. 14, x. f.), and in this kind, and also in *Myoxus* (Plate XXV, fig. 8, x.), and *Sciurus* (Plate XXV, fig. 14, x.), the xiphoid is spatulate, and comparatively narrow.

Ordo—"INSECTIVORA."

Examples.—Talpa, Sorex, Amphisorex, Crocidura, Chrysochloris, Erinaceus.

The Marsupials, the Edentates, the Rodents, and the Insectivores, all lie in a circle round the Monotremes. The cranium of the Mole and the Shrew is but little modified, in *essentials*, from that of the Echidna, and the regions under review here will display to us the congenerous nature of these Monotrematous and Insectivorous types. The scapula (Plate XXV, fig. 16; Plate XXVII, figs 1, 2, 3, 10, 15, 18, 22; and Plate XXVIII, figs. 1—3) is high and narrow; has generally a very large forked acromion (ac., m. ac.), and a very slight differentiation of the supra-scapula (s. sc.). In the Mole (*Talpa europæa*), which comes nearest the Echidna, the scapula (Plate XXVII, figs. 1—3) is extremely high and narrow, and appears to be ossified entirely from one centre, the coracoid process being absent; for there is a large coracoid cleft away completely from the scapula: the acromion (ac.) and the supra-scapula (s. sc.) are mere polished bosses. The meso-scapular spine (m. sc.) almost dies out in the pinched waist of this phalangoid scapula (see in the young, Plate XXVII, fig. 15, m. sc.); the "notch," which differentiates the meso-scapula below, is very shallow (figs. 1—3). Primarily the Mole's scapula (fig. 10, an *inner* view) is a long, flat ray; and the only sign of morphological division it has arises from the correlation of the outer surface to the "infra-" and "supra-spinatus" muscles. In the Shrews (Plate XXVIII, figs. 1—3, *Sorex tetragonurus*; and Plate XXVII, fig. 22, *Crocidura* —— ?) the scapula is very narrow; it has a small supra-scapular epiphysis (s. sc.), and another in the small coracoid hook (cr.); this latter is early fused into the scapular bone. The meso-scapular spine (m. sc.) is nearly as high as the whole bone is broad (Plate XXVIII, figs. 2, 3, (m. sc.); it rises to its highest at the upper third, and leans backwards over the infra-spinous fossa. The notch severing the acromial portion from the neck is very large (fig. 3, ac.); and the acromion spreads into two rays with dilated ends (Plate XXVII, figs. 22 and 25, ac., m. ac.; and Plate XXVII, figs. 1—3, ac., m. ac.). Of these acromial rays, the foremost (ac.) is tied to the cartilages that surmount the clavicle (cl.), and the metacromion (m. ac.) is free. In *Chrysochloris capensis* (Plate XXVII, fig. 18) the supra-scapula (s. sc.) is merely a neat upper selvedge of bone, which helps to form the outspread, pentagonal part of the meso-scapula (m. sc.). At the lower part of the pentagon the spine is of normal breadth; and it then suddenly sends a large quadrate plate backwards as a roof to the supra-spinous fossa (fig. 19), leans backwards to its base, and for the remaining part is very broad at the top, and forms a large semilunar bar, the terminal third of which is the metacromion. The acromion proper (ac.) is marked by an angular process in front of the metacromion (m. ac.). The outline of the præ-scapula (p. sc.) is convex, and that of the post-scapula concave; the former region is the largest, contrary to what is seen in the true Shrews (Plate XXVII, fig. 22; and Plate XXVIII, figs. 1—3). The coracoid (cr.) of the Chrysochlore is a small epiphysis. The general outline of the scapula in the young Hedgehog (*Erinaceus europæus*) is that of a pruning-knife; it is not so much bent, and yet it is of the same type of form as that of the *Platypus*, and, indeed, of a Bird; the supra-scapular region (s. sc.) being greatly hooked. The two fossæ, and therefore the præ- and post-scapulæ (p. sc., sc.) are nearly equal; the meso-scapular spine (m. sc.) is very large, and has an immense acromion (ac.) with a rounded metacromial lobe (m. ac.): the coracoid region (cr.) is more developed than in the Shrews. The clavicle of the Mammalia (excluding the Monotremes) is always rendered *compound* by being correlated to certain parts of the Shoulder-girdle; in the Mole this composition, and the metamorphic processes involved in it, are of the highest interest. My earliest Mole-embryos were two or three days old, the next a week or two; from the study of the earliest I have arrived at the following conclusions as to the structure of these parts. In a very early stage the whole Shoulder-plate is as simple as that of the Chamæleon (see Plate XI, fig. 4); it then undergoes transverse segmentation. The first cleft completely cuts off the scapula from the coracoid mass below (Plate XXVII, fig. 10, gl. cl.); this cleavage is through the glenoid fossa, in the unossified space shown in the figure of the Chamæleon's Shoulder-plate, between p. sc. and gl. This quadrate mass undergoes further cleavage, for a large slice is cut from it both above and below; these slices I propose to call the first and fourth "coracoid segments" (Plate XXVII, figs. 11—13, c. s. 1, c. s. 4). The mass of cartilage between these plates becomes rapidly scooped in front; and in this concavity a simple clavicle (cl.), is formed, at first of a lenticular shape, but afterwards becoming a very solid *carpiform* bone (see figs. 11—13, my youngest Mole). The manner in which this thick clavicle is imbedded in cartilage is shown in fig. 10 (nearly four diameters); it is *free* in front, and on its outer and inner sides; but above, below, and behind it is enclosed in the hollowed coracoid cartilage. This hyaline cartilage suffers ossification from the clavicle faster than it grows; and posteriorly all the cartilage eventually vanishes; above and below, however, this is persistent, and forms the articular cartilage of the adult (Plate XXVII, figs. 8, 9, cl., c. s. 2, c. s. 3). In the youngest stage, the transformation of the cartilage-cells of the coracoid nearest the bony substance of the clavicle is clearly shown (Plate XXVII, fig. 14, cl., c. s. 2,—150 diameters); a tract of fine fibrous tissue is seen separating the persistent cartilage from the upper segment (c. s. 1), which is composed of much smaller cells than the scooped mass; in the adult the flat segments are composed of longer celled cartilage than that which is attached to the clavicle (Plate XXVII, fig. 9, c. s. 3, c. s. 4).

The last-quoted figure, which is a slice from the sternal end of the adult Mole's "coraco-clavicle" shows a very clean fissure between the hyaline "meniscus" (c. s. 4) and the hyaline articular cartilage (c. s. 3), but the cavity on the clavicular side of the meniscus is extremely imperfect; in the youngest specimen it appears in some degree (Plate XXVII, fig. 13, between and below c. s. 1, and c. s. 2). The second stage (Plate XXVII, figs. 15—17, three-and-a-half and seven-and-a-half diameters) shows how the clavicular bony matter gains upon the scooped coracoid behind; how that the well-known coracoid foramen (cr. f.) seen also in the adult (fig. 5), pierces the clavicle itself; and the manner in which the lower meniscus spreads out to articulate with the præ-sternum (p. st.) above. I consider that the lowest segments, right and left, are the moieties of a highly modified "omosternum;" but the other segments answer to much more than those we find in the other Mammalia. In *Crocidura* (Plate XXVII, figs. 25 and 26, m. sc. s.) the meso-scapular segment is cut through, leaving one part to ossify by itself, and the other to grow on to the clavicle; in this type the upper meso-scapular piece answers to a fragment of the "first coracoid segment" of the Mole, and the lower to the second; whilst the distal præ-coracoid (fig. 23, p. cr.) is a small rudiment of the third layer of cartilage in the Mole (Plate XXVII, fig. 8, c. s. 3). The omosternum and epicoracoid of *Crocidura* (Plate XXVII, fig. 23, o. st., e. cr.) are autogenous rudiments of the great cartilaginous flap which in the Mole articulates with the upper surface of the sub-carinate cervical part of the manubrium (Plate XXVII, figs. 4 and 6, cl., p. st.; and fig. 15, p. st., c. s. 4).

As a rule, the clavicle is long, slender, and curved in the Insectivora (Plate XXVII, figs. 18 and 22; and Plate XXVIII, figs. 1—3, cl.): in *Erinaceus* it is stouter (Plate XXV, figs. 16 and 19, cl.); in this type the mesoscapular segment (fig. 18, m. sc. s.) is partially ossified by the clavicle.

In *Chrysochloris* (Plate XXVII, fig. 18, m. sc. s.) it is a small, but very distinct bone, very independent of the clavicle; this is illustrated by *Crocidura* (figs. 22 and 25, m. sc. s.), where it is very distinct from both the acromion and clavicle, and where a secondary part is joined to, and partly ossified by the clavicle. In *Sorex tetragonurus* the upper part is not cut off from the clavicle (Plate XXVIII, figs. 1 and 4, m. sc. s.); it is ossified independently, but feebly, by one large and two smaller endosteal centres. In the Hedgehog the meso-scapular segment and præ-coracoid, which are soft in the young (five or six days old), are separately ossified in the adult; whilst the omosternum, in the early state, is a mere rod of fibro-cartilage, which is still more deteriorated in the adult (Plate XXV, figs. 16, 17, 19, p. cr. o. st.). In *Sorex* and *Crocidura* the præ-coracoid has its own lenticular osseous centre within; and in the old *Amphisorex fodiens* (Plate XXVIII, fig. 8, p. cr.) this part is quite ossified. In *Crocidura* (Plate XXVII, figs. 22, 23) the omosternum (o. st.) is an elegant claw-shaped ray of hyaline cartilage, with an oval bony grain inside; but in *Sorex tetragonurus* this is nothing but a fibro-cartilage (Plate XXVIII, figs. 1 and 5, o. st.). I see no epicoracoid in either the Hedgehog or Chrysochlore; but in *Crocidura* (Plate XXVII, figs. 22, 23, e. cr.) it exists on each side as an elegant cordiform flap, partly hardened by endostosis. Supposing this piece and the omosternal to be one, the relation of such a flap to the upper ridge in front of the præ-sternum would be exactly what we see in the Mole (Plate XXVII, fig. 15, c. s. 4, p. st.) with regard to the distal flap-shaped *Meniscus*. The epicoracoids of the Common Shrew (*Sorex tetragonurus*) meet on the anterior edge of the præ-sternum, and then coalesce (Plate XXVIII, figs. 1 and 5, e. cr.). This is a repetition of what we have seen in the *Lepidosiren*, *Cottus*, &c., amongst the Fishes: this is also to be seen in the Water-Shrew (fig. 8, e. cr.).

The Sternum is very variable in the Insectivora; it becomes segmented completely, though without *cavities*, in the Shrews (Plate XXVII, fig. 22; and Plate XXVIII, fig. 1); the segmentation becomes imperfect behind in the Mole (see Plate XXVII, figs. 7, 10, 15); and a section of that of the adult shows that a nucleus had been left between the præ- and meso-sternum, which becomes an epiphysis (fig. 7, ep.). In the Hedgehog (Plate XXV, fig. 16 and 19, old and young) I find nothing more than feeble transverse notches below. The præ-sternum is bilobate in front in the Hedgehog, and trilobate in the Shrews; in the Chrysochlore (Plate XXVII, fig. 20, an ideal section, four diameters) it is a deep spoon, strongly keeled below. But the Mole has the most extraordinary manubrium ("præ-sternum," see Plate XXVII, figs. 4, 5, 6, p. st., old; and figs. 10 and 15, p. st., young); it is much larger than the whole of the meso-sternum (m. st.) in the young, where it is seen (fig. 10) to give off two pairs of wings; it is strongly keeled below (figs. 5, 6, and 10), save at the front part, which is cordate; above (figs. 4 and 15) it is rounded behind, scooped in the middle, and carinate in front. The hinder lateral projections carry the first sternal ribs (figs. 10 and 15, s. r. 1); and between the manubrium and the first meso-sternal we find the most perfect cleft.

In the adult (Plate XXVII, fig. 6, st. f.) there is a fenestra, tending to separate the keel from the body of the præ-sternum. The ossification of the Sternum in the Insectivora is by *ectostosis*, seen in the youngest *Talpa* (Plate XXVII, fig. 10, pl. o. 1), where the bony matter is surrounding the hinder third of the præ-sternum: in the next stage (fig. 15, pl. o. 2, m. t., o.) there are three more azygous pleurosteal rings, and a "metosteon." The Shrews conform to this type; but in the Hedgehog (Plate XXV, figs. 16 and 19), which has the Sternum broad and flat behind, as in the Ruminants, the meso-sternal bones are symmetrical. As a rule, the xiphoid part of the sternum has a long ectosteal shaft, terminated by a rounded, flat lobe; which, in old age, becomes partly ossified by *endostosis;* this second "metosteon" is symmetrical in *Sorex* (Plate XXVIII, fig. 1, x.), and in *Crocidura* (Plate XXVII, fig. 22, x.). These bony tracts are an exact imitation of the primordial "xiphisternal horns." The xiphisternum of the Hedgehog (Plate XXV, figs. 16, 19, x.) is emarginate by a "primordial notch," like the "præ-sternum." There is no joint between the vertebral and sternal ribs in the Insectivora; the latter are always ossified by *endostosis*, yet they become very dense in the Mole. In *Chrysochloris* the "costa intermedia" appears (Plate XXVII, fig. 21, i. r.), and is sometimes represented by two distinct ossicles.

Ordo—"CHEIROPTERA."

Examples.—Scotophilus, Plecotus, Molossus, Pteropus.

The Cheiroptera do not appear to be far removed from the Insectivora; and although their limbs, especially their fore-limbs, are modified considerably in relation to their habits, yet, the morphology of the two groups is essentially the same. The scapula has its infra-spinous part greatly developed, and in some instances outdrawn—as in Birds, leaving the supra-scapula a mere angle (Plate XXVIII, fig. 18, sc., s. sc.); the præ-scapula (Plate XXVIII, figs. 11—13, p. sc.—*Scotophilus*, 5 diameters, and fig. 18, p. sc., *Molossus*, 2½ diameters) is narrow, and projects forward; the meso-scapula (figs. 12, 13, and 18, m. sc.) is short and moderately high; but its acromion process (ac.) is large and simple, and stands out from the neck of the scapula. The infra-spinous region (sc.) is divided, by a ridge, into two fossæ in *Molossus* (fig. 18), and by two ridges into three fossæ in *Scotophilus* (fig. 12); the sub-scapular plane is sub-divided into three fossæ in the latter (fig. 11); in *Molossus* there are two very deep valleys. In *Plecotus, Molossus* (fig. 18, cr.), and *Pteropus*, the coracoid is simple, long, incurved greatly, and ossified separately by *ectostosis;* in *Pteropus* there is an epiphysis at its free end; in *Scotophilus pipistrellus*, however, the coracoid is bifurcate, and the upper fork turns towards the præ-scapular hook (fig. 13, cr. p. sc.); the glenoid cavity (gl.) is very deep. The clavicles (cl.) are very long; and in *Pteropus* they are very stout as well (fig. 9, cl.). The meso-scapular segment is soon lost on the upper end of the clavicle, but the præ-coracoid can be found on the lower end; it ossifies separately (figs. 9, 10, 16, 17, p. cr.). The "omosternum" is reduced to the form of a cuneiform meniscus; but in the young Pipistrelle, two or three months old, it is seen to be *well ossified* separately (see figs. 14 and 15, o. st., 10 diameters). This is a most instructive condition, connecting the inter-articular fibro-cartilage of those Mammals that have strong clavicles and degenerate omosternals, with those possessing feeble clavicles and long, separately ossified omosternals.

In the four kinds studied by me, I find an epicoracoid (figs. 9, 10, 11, 14, 15, 17, e. cr.); it is a flat, reniform flap of cartilage, feebly ossified by endostosis, and wedged in between the clavicle and first rib (s. r.).[1]

The Sternum of the Bat is very *human* in appearance, and, indeed, in the degree of its segmentation; for in *Scotophilus* (fig. 11, p. st., m. st., x.), and in *Molossus*, there are only two transverse clefts—the primary clefts—which cut up the whole bar into "præ-," "meso-," and "xiphi-sternum;" the two latter segments are not divided in *Plecotus auritus;* but in *Pteropus*, which comes nearer to the Lemurs, there are *secondary* subdivisions (fig. 9, m. st. 2). The ossification of the Bat's Sternum, however, is the same as in the Insectivora, viz. by ectostosis; of this I am satisfied by Pipistrelles fresh from the nest, where, so soon, there is an epiphysis (ep.) fore and aft of the first cleft (figs. 11, 15); there are two pairs at this part in *Pteropus edulis* (fig. 9, ep.).

[1] This is very note-worthy, for these *Rear-mice* are thoroughly Mammalian in every particular; and their power of flight is not obtained at the expense of any Class-character: although akin to the Insectivora, they are *above* them; and pass towards the Lemurs, through the Flying-cat and the Aye-aye.

The præ-sternum is trilobate in front (figs. 9, 11, 14, 15, 17, p. st.), and is strongly keeled (k.); the carination is continued to the end of the proximal "metosteon" (fig. 11, x.) in *Scotophilus*. In *Plecotus auritus* (fig. 17, p. st., f.), the præ-sternum is differentiated into an "ento-," and two "pleuro-sternal" regions by a pair of small "fenestræ." This is exactly like what we see in *Stellio* (Plate 11, fig. 2, st. f.).[1] The xiphoid segment has an ectosteal "metosteon" in its handle; the broad blade (fig. 11, x.) is ossified by endostosis in old age. The sternal ribs are not segmented from the vertebral (s. r., v. r.), and they ossify, not densely, by endostosis. It is common, for the first floating rib to be uncleft from the last sternal rib; this is seen in *Scotophilus* (fig. 11) and in *Plecotus*. In *Molossus* this condition exists, but in that type the second floating rib is also continuous with the first. The arrested morphological cleavage of the lower part of the thorax in the Bats is one of the most marked deviations these creatures make from the Insectivorous types.

Ordo—"CARNIVORA."

Examples.—*Felis, Thalassarctos, Otaria, Phoca.*

The rest of the Mammalia are possessed of a much more highly developed brain than those which have been spoken of; and are thus the noblest of the Class. Working in a line, I ought to pass at once to the smooth-brained Lemurs, the lowest of the Primates; but in that way I should reach *Man*, without coming across the Carnivora, the Cetacea, and the Herbivora (Pachyderms and Ruminants).

In many respects the Carnivora may be said to form a culminating Order, of this the highest Class; and yet, for the first time, we find in them the perfect segmentation of a morphological element, which is half cloven from the common mass in my lowest instance (the Ray). This is the "præ-scapula;" it forms the foremost of the three scapular bars in the Skate (Plate 1, fig. 2, p. sc.): in an embryo Kitten ($2\frac{1}{3}$ inches in length, see Plate XXX, figs. 1 and 2, six and twelve diameters) it is completely severed from the rest of the blade-bone. In the Sloths (Plate XXI, c. s. f.), and in the Ant-bear (Plate XXIII, fig. 21, c. s. f.), the foremost "fenestra" of the Skate (Plate I, fig. 2, c. s. f.), and of the Iguana (Plate IX, figs. 1 and 2, c. s. f.), partly severs both the præ-coracoid and the præ-scapula from the rest of the Shoulder-girdle moiety. In the Pangolins, we have seen the meso-scapula partly separated from the post-scapula by a fenestra, re-adopted, as it were, from the Iguana (Plate IX, figs. 1 and 2, sc. f.), and from the Skate (Plate I, fig. 2, sc. f.); but the "meso-" is never separated entirely from the "post-scapula." Hence we see that this complete segmentation of the præ-scapula in the Cat is as little to be accounted for, morphologically, as the perfect cleaving of the "supra-scapula" from the rest of the scapula in the Skate and the Sturgeon—a state of things not seen elsewhere. The præ-scapular region of the Cat is seen to be largely produced forwards in the adult; in the embryo a sinuous tract of connective fibres completely insulates the projecting portion from the root of the meso-scapular spine, which is here very broad (Plate XXX, figs. 1 and 2, p. sc., m. sc.). An ectosteal layer of bone ossifies both the meso- and post-scapular region; but the præ-scapula has its own osseous centre. The meso-

[1] M. Blanchard ('L'Organisation du Règne Animal, Mammif. Cheiropt.,' Livr. ii, Pl. 1) has figured these in *Vespertilio murinus*.

scapula of the Cat has a deep spine, which leans backwards over the infra-spinous fossa (fig. 1, m. sc.); this spine becomes free below, and gives off a broad "metacromion" (m. ac.); the acromion turns forwards. The area of the "supra-" and "infra-spinous fossæ" is nearly equal; in the adult the supra-scapular region is small, and ossifies very slowly; the coracoid (cr.) is very small, and sends inwards and backwards a small curved beak. In the newly-born Leopard the scapular bones are much advanced (fig. 3, p. sc., sc.—one and one-third diameters), and are united by a dentate suture, which lies further off from the spine than in the embryo Cat; this is a growth-change: the supra-scapular (coraco-scapular) notch is a large half-moon. In the newly-born Polar Bear (fig. 4, natural size), this notch is very small, deep, and rounded; the coracoid boundary, below (cr.), is a very blunt projection from the glenoid cup; and the præ-scapular bone (p. sc.) only occupies a smallish square plot at the lower angle of the very broad supra-spinous fossa. The spine of the meso-scapula (m. sc.) is deep, and leans backwards, as in the Cat, but the acromion is not forked, and has a pyriform outline: the whole blade-bone at this stage is nearly as broad as high, and the whole supra-scapular region (s. sc.) is semioval in outline. The embryonic form of the Bear's scapula is much like that of the adult Seal (*Phoca grœnlandica*, fig. 8, one-quarter natural size), but does not curve backwards so much, and has a larger acromion; yet the scapulæ are of precisely the same type; the leaning back of the spine at the middle, the bulging of the præ-scapula, the size of the supra-scapular notch, and the great abortion of the præ-coracoid—these are alike in both. The Seal has a very large supra-scapular epiphysis (s. sc.), for in that type the scapula has something of the arcuate form seen in the Platypus. In the half-ripe embryo of the Cat the clavicle and its correlates had not appeared; nor could I find them in the Polar Bear, just born; but in the new-born Leopard (fig. 3, cl., p. cr., m. sc. s.) these parts are present, although very small: they become one, twisted, styloid bony piece in the adult: there is no omosternum. In the early stage of the Kitten (fig. 1) the Sternum shows a considerable amount of commenced segmentation; this, however, is only completed between the præ- and meso-sternum (see fig. 3, p. st., m. st.). As yet, the first rib is not ossified in the vertebral region; nor is it segmented from the Sternum below; the latter is not at all ossified. It terminates in front in a short (p. st.), and behind in a rounded, oblong flap (x.); this latter becomes somewhat outspread afterwards (fig. 3, x.), as shown in the new-born Leopard. In this instance we see the first sternal rib segmented from the Sternum (s. r. 1); the præ-meso-sternal transverse cleft, with no successors; the absence of cleft between the vertebral (v. r.) and sternal ribs; and the phalangiform, *ectosteal* sternal bones (p. st., m. st., x.). The same things are seen in the young Bear (figs. 5 and 6), but there is no transverse cleft behind the manubrium (p. st.); the last meso-sternal (fig. 6, m. st.) has but just commenced, and there is, as yet, no "metosteon" in the short xiphoid (x.). In the adult *Otaria* (fig. 7, one-quarter natural size) there is, as far as I can see in the newly dried Sternum, no perfect transverse segmentation of the Sternum, which ossifies by *ectostosis;* nor is there any segmentation of the vertebral from the sternal rib (v. r. 1, s. r. 1): these latter do not ossify, except, perhaps, slightly, in extreme old age. The cervical part of præ-sternum (p. st.) is very long; is carinate below, and continues soft in front; the long, elegant, spatulate xiphoid (x.) has a long "metosteon," which does not occupy all the "handle" of the spatula, the rest, and the pyriform end, continuing soft.

Ordo " CETACEA."

Example.—Delphinus—— ?

The scapula in the Cetacea (Plate XXIX, fig. 22, embryo of *Delphinus* ——?, nine inches long,—two diameters) is fan-shaped, being very broad in its supra-scapular region; the anterior angle is apt to be premorse, and the posterior greatly extended backwards. The posterior margin is of great extent in this species; the præ-scapular region (p. sc.) is of very small extent, and the meso-scapular spine is very small, is turned forwards, and gives off very suddenly an adze-shaped acromion (ac.): this process is but little elevated above the coracoid (cr.), which has the same shape, but is, in this instance, twice as large. The ossification of the body of the scapula is by ectostosis, but there is a separate endosteal patch for the coracoid. In the adult *Balæna mysticetus* (see Memoirs on the " Cetacea," by Eschricht, Reinhardt, and Lilljeborg, Ray Soc., 1866, p. 128[1]) the scapula is very regularly fan-shaped, with three nearly equal sides; its acromion is feeble, and its coracoid feebler still, being a rounded process, one-third the size of the feeble acromion. This latter process attains its highest development in *Euphysetes Macleayi*, Krefft ('Proc. Zool. Soc.,' 1865, p. 712, fig. 6): in that type the coracoid is also large, but only half as large as the pedate acromion. The broadest of these flabelliform scapulæ is seen in *Sibbaldius antarcticus* (Burmeister, 'Proc. Zool. Soc.,' 1865, p. 714); and in this kind the supra-scapular margin is elegantly arcuate, and the acromion very long. A similar supra-scapula is seen in *Balænoptera patachonica* (Burmeister, 'Proc. Zool. Soc., 1865, p. 195); but in this species the supra-scapular margin is sub-angular.

The coracoid is aborted in the Cape Whales (Esch. and Reinh., *op. cit.*, p. 128): in the genus *Pseudorca* (Ibid., p. 213), the scapula is very similar to that of the Dolphin; the acromion, however, is longer than the coracoid, and the posterior angle is more truncated. There is nothing below the glenoid fossa belonging to the Shoulder-girdle, but the Sternum and its surroundings show very interesting characters. In the embryonic Dolphin (Plate XXIX, fig. 22), the Sternum has its highest Cetacean development; but it is arrested at the same morphological stage as that of certain Lizards (see Plate X, fig. 4, *Trachydosaurus*). The two moieties have coalesced in front, in the middle, and near the end; but there is an oval fontanelle (such as is common in the Lizards) in the præ-sternum (p. st., f.), and a large part of the meso-sternum and the hinder part of the præ-sternum is occupied by the primordial fissure. The præ-sternum is very broad; has a lunate emargination in front, then a pair of rounded projections from the first ribs, then an elegant pair of retral horns, and it then becomes suddenly reduced to scarcely more than half its breadth. From the insertion of the second ribs the meso-sternum becomes gradually narrower, widening, however, to join each pair of sternal ribs; and then, behind, breaking out into a pair of short horns, to which are articulated the fifth sternal ribs: this is precisely what takes place in *Trachydosaurus*, even as to the number of the ribs. Submesially, the substance which was cleft to form the floating ribs (fig. 22) left no spare tissue to be continued as xiphisternum; but the diverging ends of the meso-sternum (m. st.) are the termination of the costal key-stone. There are three pairs of "pleurostea" (pl. o., 1—3), the first pair being manubrial; these are ectosteal, but endostosis is set up at once, and the two processes are nearly synchronous from the beginning (see a section of the second pair of centres, fig. 23, pl. o., 2, eight diameters, and part of this section, fig. 26, sixteen diameters): it is here seen how equal in extent the two deposits are. The vertebral and

[1] Edited by W. H. Flower, Esq., F.R.S.

sternal ribs are all segmented from each other, and the latter become completely ossified, but by endostosis *originally;* there are five pairs of floating ribs, with a free inferior part, and then five pairs entirely vertebral. Neither the lateral joint, nor that of the sternal rib with the Sternum, nor that of the "capitulum" of the vertebral rib with the "centrum," are synovial. The junction of the sternal rib with the Sternum (fig. 24, st. s. r. 2, eight diameters) is by the intervention of a mass of fibrous tissue; between the sternal and vertebral ribs (fig. 25, v. r. 3, i. r. 3, s. r. 3, eight diameters; and fig. 28, v. r. 2, i. r. 2, and s. r. 2, eight diameters; and fig. 30, v. r. 3, i. r. 3, and s. r. 3, sixty-four diameters) there is, in the midst of a mass of connective fibre, a cartilaginous nucleus, which is partly split, and which answers to the intermediate rib. On the "capitulum" of the vertebral rib (fig. 27, c. p.) there is a similar nucleus, and the tuberculum (t. b.) is attached to the transverse process (t. p.) by fibrous tissue. The condition of the shortest form of the Cetacean Sternum, that of the fœtus of the Greenland Whale (*Balæna mysticetus*), is well shown in the invaluable work by Eschricht and Reinhardt (p. 118). The whole of this cartilaginous Sternal plate is wedge-shaped; its halves have completely united; it has a blunt-pointed, free xiphoid, which grows directly from the trilobate præ-sternum: as in the Newts, there is no meso-sternum. The end of the first vertebral rib (b) which does join the Sternum, and that of the second (b′) which does not, is capped with fibro-cartilage; then comes the fibro-cartilaginous mass (è), and then the sternal rib (d) composed, as in the Dolphin, of hyaline cartilage. It is evident that the two layers of fibro-cartilage (c. e.), seen in the embryo of *Balæna* answer to the split intermediate part shown in the Dolphin (Plate XXIX, fig. 30, i. r. 3). In *Balænoptera robusta* (Lilljeborg *op. cit.*, p. 283, fig. 4); in *B. rostrata* (Flower, 'Proc. Zool. Soc., 1864,' p. 393, fig. 9); in *Physalus antiquorum* (ibid., fig. 7); in *Sibbaldius Schlegelii* (ibid., fig. 8) and others, the Sternum is merely a præ-sternum (manubrium with a free xiphoid rudiment): this is extremely short in *Sibbaldius.* In the Sperm Whale (see Mr. Flower's forthcoming paper in the 'Trans. Zool. Soc.' for this year) there are three pairs of sternal bones[1]; and thus this type approaches the Dolphins in the structure of the Sternum. In the simple sterna there appears to be but one osseous centre, or perhaps a pair of symmetrical bones in some cases; but in the Sternum of a young *Balæna australis*, which is deeply bilobate in front, I found an ectosteal centre, *in front,* in the crescentic emargination: it had commenced at the selvedge.

Ordo "SIRENIA."

Example.—Manatus Americanus, Cuv.

The scapula of the Dugong and Manatee is very much like that of the Seal (Plate XXX, fig. 8), but the processes are more developed, especially the acromion, in the Manatee. That of the Dugong, however, is not unlike the same part in the embryo of the Horse, which has a scapula very much less triangular than the Cow. This bone in the Sirenia is totally unlike what is seen in the Cetacea; having a goodly supra-spinous fossa—nearly as large as the infra-spinous; whilst the acromion and coracoid have none of the parallelism seen in the latter. The resemblance of the scapula in one case to a fan, and in the other to a woodman's bill-hook, is seen in

[1] Mr. Flower has shown me that, as a rule, there are three pairs of sternal bones in the Sperm Whale; of these, the first and second pairs may unite together; or the second with the third. There is a large manubrial fontanelle; and the primordial fissure is never quite obliterated. In an old skeleton from Scotland (in the British Museum) the third segment is only partially ossified by an azygous bone.

the Reptiles as well as in the Mammals (see Plate X, fig. 1, sc., *Trachydosaurus;* and fig. 7, sc., *Psammosaurus*). The lower part of the Shoulder-girdle is entirely absent in the Sirenia; in their Sternum they are isomorphic with the Cetacea. In the adult Dugong there are five serial sternal bones (see M. Fred. Cuvier, in Todd's 'Cyclopædia of Anatomy and Physiology,' Article "Cetacea," p. 569); in the young (three feet six inches in length, Hunterian Museum) I find the Sternum in a higher morphological stage than that of the Dolphin, for the halves are completely fused, and there is a free (though short) xiphoid process. Contrary to what is seen in the Dolphin, the Sternum becomes wider backwards, but the præ-sternal ectosteal bone is the first to appear: in the specimen just referred to it is the only centre present; it is a large, oblong bone, not reaching the rounded front of the very long cervical portion of the præsternum: behind, it reaches the first pair of ribs. The rest of the Sternum, at this stage, is wholly unossified, and has two more pairs of sternal ribs articulating with it: the xiphoid process is very broad and short. The sternal ribs are stout, and of considerable length: they are in this instance still soft, but ossify ultimately by endostosis; they are segmented from the ribs, as in the Cetacea. In the Manatee (*Manatus americanus*) the Sternum agrees with the *simple* Cetacean type (see Plate XXIX, fig. 21, the upper view, one-third natural size, of the left half of the sternum of a fresh specimen, dissected by Dr. Murie, which was five feet five inches long). The whole Sternum is lyriform, emarginate in front, cuneiform behind, soft at both ends, and having at this stage (not adult) only one bony shaft, which is somewhat carinate below. Behind the two square, diverging præ-sternal horns (p. st.) the Sternum is suddenly narrowed; it then bulges out, where it meets the only pair of ribs attached to it, namely, the second, and then gently and sinuously converges its margins until it ends in the soft xiphoid wedge. The first pair of ribs (v. r. 1, s. r. 1) approach the second at a right angle, but do not reach them, being merely attached by ligament. A mass of fibrous tissue connects the small pisiform, hyaline sternal rib with the ossified end of the vertebral. There is a hyaline mass at the end of the second pair of ribs, then a fibro-cartilaginous mass (costa intermedia), and then a goodly terete sternal rib, unossified, and composed of hyaline cartilage; this is attached to the Sternum by a strong fibrous ligament. The third sternal ribs only reach halfway to the Sternum (s. r. 3), the rest being completed by a fibrous band, so that they are floating ribs: these are less than those of the second rib, and unite with their vertebral part (v. r. 3) in a similar manner, but with less evidence of an intermediate segment. Here we see that, whatever be the zoological affinities of the Sirenia, their morphology in the thoracic region is very similar to what is found in the Cetacea; as a correlate of their aquatic condition, they are arrested morphologically in a similar manner, although not to the same degree.

Ordo—" HERBIVORA."

A. Pachydermata.

Examples.—Equus, Hippopotamus, Tapirus, Sus, Hyrax.

B. Ruminantia.

Examples.—Bos, Tragulus.

From those aquatic Herbivores, the Sirenia, the passage is easy to the great Land Mammals, which are for the most part vegetable-feeders. For the skeletal regions under consideration it will be better to consider the two groups at once, as they may be characterised together as one Order; for the Ruminants are merely a specialization of the Pachyderms.

The scapula is always rather high than broad; the acromion and coracoid are always mere rudiments; there is never any clavicle nor any cartilaginous segments; the Sternum is compressed in front and depressed behind, and always ossifies by centres which are at first endosteal: these are generally azygous, but are sometimes symmetrical. The sternal ribs ossify slowly and feebly by endostosis, and are always, with the exception of the first pair, separated from the vertebral portion by a synovial cavity: in this joint the vertebral ribs are cupped, and the sternals convex. Amongst the Pachyderms, the Horse and its allies lie farthest from the Ruminants, and the Suidæ come nearest to them. The scapula of the adult Horse answers, in form, to that of the earliest differentiated condition of the scapula of the Ox (see Plate XXIX, fig. 1, Ox-embryo, one inch four lines in length,—six diameters), whilst in some of the more delicate Ruminants this bone comes near what is seen in the Rodents. The scapula of an Ass two weeks after birth is high and narrow; the glenoid region is more than half the width of the supra-scapula; the neck is both long and broad, two-fifths the breadth of the supra-scapula: this upper part is crescentic, the upper edge of the bony shaft being strongly arcuate. The bone stops abruptly in front of and above the shallow glenoid facet; and the front of the cup forms a low coracoid projection, with a wedge-shaped endosteal patch in its inside—the rudimentary coracoid. There is no acromion, for the crest (spine) is highest at the middle, and dies out towards the supra-scapula and above the neck. The supra-spinous fossa is one-third the size of the infra-spinous. In an adult *Tragulus javanicus* the whole shape is broader, the neck short, and very narrow; the deep spine forms a right angle with the supra-scapular border of the bone: this border is nearly straight; the præ-scapular region has an arcuate outline, and its fossa is only one-fifth the width of the widest (upper) part of the infra-spinous space. The supra-scapula ossifies (endosteally) very late; the spine grows downwards into a straight, sharp acromion; the coracoid process is well shown, but is short, flat, emarginate, and incurved. In the Ox-embryo (Plate XXIX, fig. 1), the supra-scapular margin (s. sc.) is arcuate; the front angle sharp, and the posterior premorse; the crest (m. sc.) is short and thick, and has no acromion; the coracoid (cr.) is a forthstanding pimple of cartilage, in front of the glenoid cup (gl.). In the same figure is seen the manner in which the simple cartilage of the "ventral laminæ" is cloven into ribs and Sternum: the distinctness of the cartilaginous masses is somewhat intensified in the engraving, for in the actual preparation there are in this early stage no distinct cavities, the clefts being filled with amorphous tissue. The two halves of the Sternum are crenate bars, which have come into contact with each other in front, but which widely diverge behind; the ribs, which are already undergoing transverse cleavage at the sterno-vertebral angle (s. v. a.) have their rounded ends lying in the notches on the outside of the sternal moieties. The deepest notches are between the second ribs, so that the præ-sternum (p. st.) is being cut off from the meso-sternum (m. st.). Behind these is a small rudiment of a "xiphi-sternal horn" (x.) on each side.

The broad first ribs (s. r. 1, v. r. 1) show no tendency to cleavage, but they are quite free of the compressed præ-sternum. In a further stage of the Ox-embryo (fig. 2, upper view of Sternnm of an embryo, two inches eight lines in length, four diameters), the two halves of the Sternum are in close contact; but the primordial fissure is perfect. The manubrium (p. st.) is rounded in front; has no *cervical* or clavicular projection; is cut off by a transverse cleft from the meso-sternum (m. st.); and articulates with the broad extremity of the first rib, and with part of the second. The meso-sternum becomes gradually very broad and flat, and its edges are produced into pedicillate, oblique cups, for the sternal ribs (s. r.): this pedicillation of the edges of the Sternum for the ribs is exactly what is seen in the Oviparous embryo. The xiphoid (x.) first narrows, and then expands towards the end, which is at present bilobate. Except in the first pair, a "cup and ball" synovial joint is found between the vertebral and sternal ribs; the latter are totally unossified at this stage; an ectosteal sheath is creeping down the former. In an Ox-embryo six inches six lines in length, ossification of the Sternum has commenced, for now the cartilage has acquired a considerable density. Sections through the fifth meso-sternal region (figs. 5 and 5*a*, m. st. 5, four diameters) show an osseous centre (pleurosteon), which towards its end (fig. 5) only reaches the upper surface of the cartilage, but in the middle (fig. 5*a*) has grown through the sternal plate. This, however, is not an ectosteal patch, for a section through the second meso-sternal region shows an *endosteal* patch lying in the very centre of the cartilage (fig. 4, m. st. 2). The sternal ribs are convex at both ends (figs. 3 and 4; in fig. 3 the ribs are in section, and the Sternum is shown from the cleft; whilst in fig. 4 the Sternum is in section and the ribs are entire: these views display the synovial cavities, and the *height* of the anterior part of the Sternum). The Sternum of an adult Ruminant (fig. 6, upper view, *Tragulus javanicus,*—nat. size) is well ossified, and secondary centres (ep.) appear at the costal hinges. In this type there is some fibrous segmentation at the second and third interspace: a slight degree of carination is seen above; but below the sternals are flat, and, indeed, somewhat concave. Here (fig. 6, p. st.) there is a cartilaginous cervical rostrum to the manubrium; the seventh and eighth sternal ribs are attached to one piece, but the eighth belongs to the spatulate xiphoid (x), which is soft behind. The breadth of the hinder part of the meso-sternum is remarkably seen in the Camel, and the bones are extremely thick as well as broad. Contrary to what is seen in the Vertebrate Sternum generally, that of the Ruminant is *widest below;* this is in conformity with *the posture* assumed by animals that chew the cud, as they lie "bedward ruminating."

In the Ass-foal (two weeks old) the Sternum is composed of one piece, thick behind, boat-shaped, and compressed in front (Plate XXIX, fig. 13, nat. size); its regions are marked out by the articular fossæ, and by elliptical patches of bone: these "pleurostea" are enclosed in the cartilage (see figs. 14 and 15, sections taken horizontally, and transversely vertical, two diameters). The "prow" of the præ-sternum (fig. 13, p. st.), has no osseous centre, and large interspaces of cartilage separate the bony nuclei. I can find no trace of a præ-mesosternal cleft. In the adult Horse (fig. 16, one sixth nat. size) the ossification is not, relatively, very much advanced; but the sternal ribs have a bony core, and there is an endôsteal mass above the joint-cavity in the second vertebral rib, which feebly indicates the "intermediate rib." In an Ass accounted forty, and in a Horse known to be above thirty years of age, I found, in my early dissections, a very imperfect ossification of the Sternum, headlands of cartilage still remaining, and the bone itself light and spongy.

In the Hippopotamus (fig. 17, young, and fig. 18, old; both one eighth nat. size) the Sternum is similar to that of the Horse, but the "prow" is longer and more dilated (vertically): in this rounded part there appears, ultimately, a "pro-osteon" (pr. o.). I cannot find true segmentation of the cartilage between the pre- and meso-sternum; nor, indeed, can I in the Indian Tapir (fig. 19, adult, one fifth nat. size). Here the "pro osteon" (pr. o.) is a more definite segment, and almost synchronous with the first "pleurosteon" (pl. o. 1). The form of the "prow" in the Tapir is intermediate between that of the Horse and River-horse. In the hinder part of the meso-sternum, however, it approaches the Pig (fig. 20, m. st.), for the last (seventh) segment has symmetrical pleurostea; there is, however, no xiphoid process: in this the Tapir is unique. In an Embryo-Pig, four inches long (fig. 10, two and two-thirds diameters) the Sternum has the same form as in the Ruminant (*Bos,* fig. 2; *Tragulus,* fig. 6), but the præ-sternal beak is more produced than even in the little Musk-deer, and it is carinate below (fig. 11, p. st.). The facets for the first ribs (which are unsegmented) are large and elevated, the rest of the perfect ribs jut into lateral fossæ, and are segmented where they form an acute angle. The whole of the Sternum and the sternal ribs are still unossified, so that ossification is later than in the Ox; but the shafts of the vertebral ribs (v. r.) are creeping downwards. A perfect joint, apparently synovial in the adult (fig. 12), is formed between the præ- and meso-sternum; the præ- and the first meso-sternal joint are ossified unsymmetrically by endostosis; then there are three pairs of meso-sternals (fig. 12, m. st., adult, one fourth nat. size), and a xiphoid bone (x.), which becomes suddenly narrow in its hinder half. In old Peccaries additional ossicles appear in the Sternum. In a Hyrax, a week or two old, the sternal bones are already well ossified, appearing, as I suppose, as endosteal patches very early, as in the Ox-embryo; there is a true joint (evidently synovial) between the præ- and meso-sternum (fig. 9, p. st., m. st., nat. size): the sternal segments are narrow, as in the Rodents. At this early age the sternal ribs (s. r.) are not ossified, and the vertebral ribs have a large piece soft below. In a Hyrax, one third adult, this remaining part has in it an endosteal patch, or "costa intermedia" (fig. 8, i. r. 2); this is also to be seen in the adult (fig. 7, i. r. 2, both reduced in size[1]). The reappearance of the "intermediate rib" in the Hyrax is noteworthy; this Lacertian segment has been seen to crop-out in the Monotremes, the Armadillos, the Chryscochlore (amongst the Insectivora), and in the Cetacea, where it comes nearest to its counterpart in the Chamæleon (Plate XI, fig. 6, i. r.). The synovial joint between the vertebral and sternal ribs, which appears first in the Crocodile, is universal in the Bird-class, and breaks out again in certain Edentata, for instance, *Dasypus, Cyclothurus,*—is constant in the Herbivora: in the Cetacea, Sirenia, and the Edentate Pangolins, the segmentation is not so perfect.

Ordo—" PRIMATES."

Examples.—Mycetes, Jacchus, Cercocebus, Pithecus, Homo.

This group might have followed either the Sciurine Rodents or the Bats; they both approach it, but do not altogether agree with it. It is easily characterised: the scapula is obliquely triangular (Plate XXX, figs. 9, 12, 17, 21), and the processes are well developed; the clavicle and its correlates are all present, the "omosternum" being converted during growth into a "meniscus." The manubrium is moderately broad, and generally separated by a transverse tract of fibre from the *continuous* meso-sternum; and the xiphi-sternum is only partly severed from the meso-sternum by notches, and is only moderately broad terminally. The Sternum is broad in flat-chested Man, and three of the meso-sternal region are ossified by symmetrical "pleurostea" (fig. 15); the whole of the meso-sternum is thus ossified in the Orang (fig. 16), and it has no

[1] The first costal arch of the Peccary is not segmented at the infero-lateral angle like the remaining ribs, whether fixed or "floating;" and the sternal ribs are ossified by endostosis (fig. 8, s. r.): supernumerary ossicles appear in the sternum of the adult, as in *Tragulus javanicus.* In the young Indian Elephant, as in the Tapir, the last meso-sternal is symmetrical.

appearance of a præ- and meso-sternal cleft. In the lower types the Sternum is more like that of a Rodent; but, as in Man (fig. 14), the bony deposit is endosteal (fig. 17*a*, *Cercocebus*).

Lastly, the sternal ribs are slowly and feebly ossified by endostosis, and have no transverse cleft to separate them from the vertebral ribs (figs. 9, 12, 17, 21, v. r., s. r.). In the flat-nosed Monkeys (fig. 17, *Cercocebus æthiops*, Kuhl, natural size; and fig. 21, *Jacchus penicillatus*, Geoff., one-and-a-half diameter) the scapula is very oblique, as in the Bats; the supra-scapula (s. sc.) is a moderate cartilaginous angle; the præ-scapular region (p. sc.) gives a supra-spinous fossa one-third the size of the infra-spinous; the meso-scapular spine (m. sc.) is large, and terminates in a large rounded acromion (ac.), which curves forwards, and in *Cercocebus* has an ossicle of its own (figs. 17, 18, ac.). The coracoid (cr.) is a large, blunt, decurved hook; the coraco-scapular notch is shallow; the neck of the scapula broad; the clavicle (cl.) strong and sigmoid, and capped by a meso-scapular segment of cartilage (m. sc. s.) above, and a præ-coracoid segment (p. cr.) below. In the Marmoset (*Jacchus*) the meso-scapular segment (m. sc. s.) breaks up into a small piece, which joins the top of the clavicle; and a larger (figs. 21, 22, three diameters), which is ossified separately on the right side. The omosternum (o. st.) is always converted into fibro-cartilage (fig. 20, *Cercocebus*, three diameters), between which and the præ-sternum (p. st.) there is a synovial cavity: this is not so evident between the præ-coracoid and the omosternal plate. In *Cercocebus* (Plate XVII, m. st.) there are five well-made meso-sternals, and then a "metosteon" in the handle of the xiphoid process. In *Jacchus* there are only four well developed; the fifth being symmetrical, but arrested as small epiphysoid grains of bone. The fibrous tract cutting off the præ- from the meso-sternum is not repeated; the terminal plate of the xiphoid is most outspread in the Marmoset (fig. 21).

The normal form of the manubrium is departed from in the Howling Monkeys; in *Mycetes seniculus* (Brit. Mus., see Plate XXVIII, fig. 19) the hinder half of the præ-sternum is normal; but in front its two large horns have not approached each other; are each ossified separately, the ossifications answering to those in the costal processes of the Rhea (Plate XVII, fig. 7, pro.): the thoracic part of the manubrium does not carry the first ribs, but these are attached behind the clavicles on the sides of the "horns." In *Mycetes ursinus* (?) (Mus. Coll. Surg., No. 4718 B; see Plate XXVIII, fig. 20) the first ribs are attached to their proper keystone, and also to the "horns," which are greatly cut away for the ribs close behind the clavicles.

I have not worked out the development of these parts in Man from so early a stage as I could have wished.[1] In the first stage observed by me (Plate XXX, figs. 1—3, an embryo two inches four lines long, magnified four and eight diameters) the scapula has much of its persistent form, and has its middle third occupied by an ectosteal bony sheath; the supra-scapular region (s. sc.) is large, wide, hooked in front, and premorse behind.

The præ-scapular region (p. sc.) is as small as in the Whale and the Platypus; the meso-scapular spine (m. sc.) is thick; arises from near the front, at the middle of the plate, and is only attached at its root; all the rest is free as a long and stout acromion (ac.), which runs downwards, and then turns forwards and inwards as a hook. The coracoid (cr.) is a blunt hook;

[1] This has, however, been done by M. Gegenbauer in his most valuable work, 'Untersuchungen zur vergleichenden Anatomie der Wirbelthiere,' 1865; Zweites Heft.; pp. 15—17. It is there shown that a large-celled cartilaginous band is continued from the acromion to the præ-sternum; here, however, the clavicle is not the ectosteal sheath to this band, but merely grafts itself upon the cartilage.

the glenoid cup is shallow; the clavicle (cl.) is stout and sigmoid; it has drumstick-shaped ends formed of hyaline cartilage; these are the remnants of a rod primarily developed quite independent of the clavicles. The meso-scapular segment (fig. 10, m. sc. s.) is attached by fibrous tissue to the acromion (ac.), and a synovial cavity has commenced at this part; at the other end the cartilage has been cleft into two segments: one, the præ-coracoid (fig. 11, p. cr.), has become hyaline cartilage, and is in close contact with the bony clavicle; whilst the distal piece (o. st.) has become fibro-cartilage. The Sternum, at this stage, has not become segmented from the first rib (s. r. 1) on the right side; the manubrium (p. st.) is cut off, by fibrous tissue, from the meso-sternum (m. st.), the two halves of which are still distinct (st. f.); the xiphoid region (x.) is also double, and is pinched, in some degree, off from the meso-sternum. Ossification is advancing along the vertebral ribs (v. r.), but all the rest is soft. At the next stage (fig. 12, an embryo five inches six lines in length, one-and-a-half diameter) the scapular shaft is spreading; the præ-scapular region (p. sc.) is becoming wider, and the coracoid (cr.) is more hooked inwards. A synovial cavity is now clearly seen between the acromion (ac.) and the meso-scapular segment (m. sc. s.); this latter part is much ossified by the clavicle (cl.), and is now a mere cap of cartilage; the præ-coracoid, however (p. cr.), is much enlarged, and has acquired its own endosteal centre, whilst the omosternal meniscus (o. st.) has become more differentiated. The Sternum has lost its primordial fissure; a band of fibrous tissue separates the manubrium from the body of the Sternum; a notch on each side marks out the xiphoid (x.); and here, in this specimen, the *left* first rib is continuous with the manubrium (p. st.).

In the next stage (fig. 13, *twin fœtus* of the seventh month, one-and-a-half diam.), the ossifying præ-coracoid (p. cr.) and the meniscoid omosternum (o. st.) are well shown; the first "pleurosteon" has appeared in the manubrium (p. st.), and the second in the first division of the meso-sternum (m. st.). The manubrial centre is shown in section in fig. 14 (two diameters), and it is seen to be endosteal. At birth (fig. 15, three-quarters of natural size) these two centres are much extended, and three pairs of meso-sternals have arisen behind them. In the adult skeleton of the Boschman (Hunterian Museum) the primordial fissure is interruptedly persistent; between the fourth and fifth sternals "fontanelles" may be seen. The xiphoid process (x.) is very variable in form (see figs. 13 and 15); it is the last region to ossify. The primary scapular shaft is supplemented, as is well known, by two epiphyses in the acromion, another in the coracoid, one along the supra-scapular border, and a fifth at the posterior (= inferior) angle.

Note.—At the last hour Dr. Günther has put into my hands his valuable Paper on that unique Lacertian *Hatteria* (see 'Phil. Trans.,' 1867, part 2, pp. 1—35, Plates 1—3). In this type Dr. Günther has discovered retral costal appendages (Pl. 2, fig. 17), like those so well known in Birds; and, what is still more interesting and important, he describes and figures a large series of abdominal splints, exactly answering to those of the extinct *Plesiosaurus.* There is an azygous series along the mid-line, each bone bent on itself at an obtuse angle; and, articulating with the ends of these, a symmetrical series (Pl. 2, fig. 26); so that this creature has three splints where the Crocodile has only two. Dr. Günther confounds the paired splints of the Crocodile with the abdominal ribs of *Chamæleo* and *Polychrus* (p. 14). The parts in *Hatteria* that correspond with the abdominal ribs of the Chamæleon are the outspread cartilages that terminate the floating ribs (Pl. 2, fig. 20); occasionally, the floating ribs meet at the mid-line, as in *Chamæleo* and *Polychrus* (p. 14).

CONCLUDING REMARKS.

The Shoulder-girdle has now been traced from the Skate, and the Sternum from the Salamander, both up to our own species.

Along this devious journey the attention of the reader has not been diverted by reference to any ideal "Exemplar," nor even by any remarks upon the teleological *meaning* of the parts described. Structural fitnesses are self-evident in most cases, and no one could be found to follow the details of a bald and positive Memoir like the present, whose own mind would not in each case intuitively supply this apparent deficiency. Not only is a teleological explanation a mere impertinence in a morphological work, it is also a biassing hindrance—a pretty golden ball that diverts the racer from his course. It may be remarked, also, that morphological science is more perfectible than teleological, the latter being often very difficult, and even, in some cases, of impossible attainment, but morphology only requires materials and patience to enable us to acquire a very clear conception of the step-by-step stages of anatomical structure. I trust that I have fairly unravelled the Shoulder-girdle from the Sternum; this was a piece of work which kept everything else waiting, and I have not found anything satisfactory on this head in the best recent works upon the subject. The distinction between the ectosteal sheath of a cartilaginous rod or plate and a tract of ossified membrane (aponeurotic bone, parostosis) is one of vital importance, and has been extremely difficult to demonstrate with absolute certainty; this, in the most difficult instances, is explained by the process of osseous grafting, such as often takes place in the Warm-blooded Classes. I have endeavoured to give a real morphological importance to many fenestræ, notches, and interspaces, that have hitherto seemed to be meaningless, but which, being rightly interpreted, throw a very clear light upon the structures which they in a greater or less degree subdivide.

On the whole, the ascent in the morphology of the regions here treated of is very regular, the greatest and most sudden changes in the parts appearing in the Birds and Mammals, an amount of metamorphosis taking place in them far beyond anything I expected to find.

These metamorphic modifications, whilst they have imparted a great charm to this piece of research, have also required no little labour and patience.

The first instance I have given of the Shoulder-girdle (in the Skate) may be compared to a clay model in its first stage, or to the heavy oaken furniture of our forefathers, that "stood pond'rous and fixed by its own massy weight."

As we ascend the vertebrate scale, the mass becomes more elegant, more subdivided, and more metamorphosed, until in the Bird Class, and amongst the Mammals, these parts form the framework of limbs than which nothing can be imagined more agile or more apt. So, also, as it regards the Sternum, at first a mere outcropping of the feebly developed costal arches in the Amphibia, it becomes the keystone of perfect arches in the true Reptile; then the fulcrum of the exquisitely constructed organs of flight in the Bird; and lastly, forms the mobile front-wall of the heaving chest of the highest Vertebrate.

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EXPLANATION OF ABBREVIATIONS.

ac. Acromion.
a. i. cl. Anterior inter-clavicle.
ap. Costal appendage.
a. r. Abdominal rib.
a. sp. Abdominal splint.

b. Brachial.
b. o. Basi-occipital.

c. Cervical rib; carpus; cartilage.
c. c. Costal condyles.
c. fm. Coracoid foramen.
c. fn. Coracoid foramen.
c. fo. Coracoid foramen.
cl. Clavicle.
c. m. Centrum of vertebra.
c. o. Coracosteon.
c. p. Capitulum of rib; costal process.
cr. Coracoid.
c. r. Cervical rib.
cr. f. Coracoid fenestra; coracoid foramen.
cr. fo. Coracoid foramen.
cr. g. Coracoid groove.
cr. n. Coracoid notch.
c. s. Coracoid segment.
c. s. f. Coraco-scapular fenestra.
c. s. n. Coraco-scapular notch.
c. s. s. Coraco-scapular suture.
ct. Cuticle.
c. v. Cervical vertebra; cutis vera.

d. Dorsal rib.
d. ep. Dermal epiotic.
d. p. c. Distal præ-coracoid.
d. p. cr. Distal præ-coracoid.
d. pt. f. Dermal post-frontal.
d. r. Dermal rays; dorsal rib.
d. so. Dermal super-occipital.
d. sp. Dermal spine.

ec. o. Ectosteal deposit.
e. cr. Epicoracoid.
e. f. External fenestra.
e. i. x. Externo-intermediate xiphoid.
en. o. Endosteal deposit.
e. o. Ex-occipital.
ep. Epiphysis; epiotic.
e. s. Ento-sternum.
e. s. f. Ento-sternal fenestra.
e. x. External xiphoid.

f. Fenestra; frontal; fibrous tissue.
f. c. Fibro-cartilage.
fo. Fontanelle.

gl. Glenoid fossa, or facet.

h. Humerus; humeral ray.

i. cl. Inter-clavicle.
i. l. Infero-lateral plate.
i. n. Inner notch.
i. r. Intermediate rib.
i. x. Intermediate xiphoid.

k. Keel of sternum.

l. Lacrymal.
l. c. f. Lower coracoid fenestra.
l. c. l. Lower coracoid lip.
l. ep. Lower epiphysis.
l. l. Lateral-line bone.
l. o. Lophosteon.
l. p. cl. Lower post-clavicle.

m. ac. Metacromion.
m. c. Medullary cavity.
m. cr. Meso-coracoid.
m. n. Meso-nasal.
m. o. Metosteon.
m. sc. Meso-scapula.
m. sc. n. Meso-scapular notch.
m. sc. s. Meso-scapular segment.
m. s. s. Meso-scapular segment.
m. st. Meso-sternum.
mt. s. Meta-sternum.
m. x. Middle xiphoid.

n. Nasal; notch.

o. Osseous deposit.
op. Operculum.
o. st. Omo-sternum.

p. Parietal; perichondrium; periosteum.
pa. s. Para-sphenoid.
p. b. Pharyngo-branchial.
p. cl. Post-clavicle.
p. cr. Præ-coracoid.
p. cr. s. Præ-coracoid segment.
p. f. Primordial fissure.
ph. Phalanges.
p. i. cl. Posterior inter-clavicle.

pl. o. Pleurosteon.
p. m. Pectoral muscle.
p. o. Pleurosteon.
p. pc. Proximal præ-coracoid.
p. r. a. Præ-abdominal plate.
pr. b. Præ-brachial.
pr. o. Pro-osteon.
p. sc. Præ-scapula.
p. st. Præ-sternum.
p. t. Post-temporal.
pt. a. Post-abdominal plate.
pt. b. Post-brachial.
p. th. Post-thoracic plate.
pt. o. Post-orbital.

r. Radius; rostrum.
r. f. Rostral fenestra.

s. Sternum.
sc. Scapula.
sc. f. Scapular fenestra.
s. cl. Super-clavicle.
sc. n. Scapular notch.
s. l. Supero-lateral plate.
s. o. Super-occipital.
s. r. Sternal rib.
s. sc. Supra-scapula.
st. Sternum.
s. t. Super-temporal.
st. f. Sternal fontanelle; sternal fenestra.
su. o. Sub-orbital.
sy. Sychondrosis; synovial cavity.

t. b. Tubercle of rib.
th. Thoracic plate.
t. p. Transverse process.

u. Umbilicus; ulna.
u. c. f. Upper coracoid fenestra.
u. c. l. Upper coracoid lip.
u. ep. Upper epiphysis.
u. o. Urosteon.
u. p. cl. Upper post-clavicle.

v. Vertebra.
v. r. Vertebral rib.

x. Xiphi-sternum.
x. f. Xiphi-sternal fenestra; xiphisternal fissure.
x. m. Xiphi-sternal muscle.
x. s. f. Xiphi-sternal fenestra.
x. st. Xiphi-sternum.

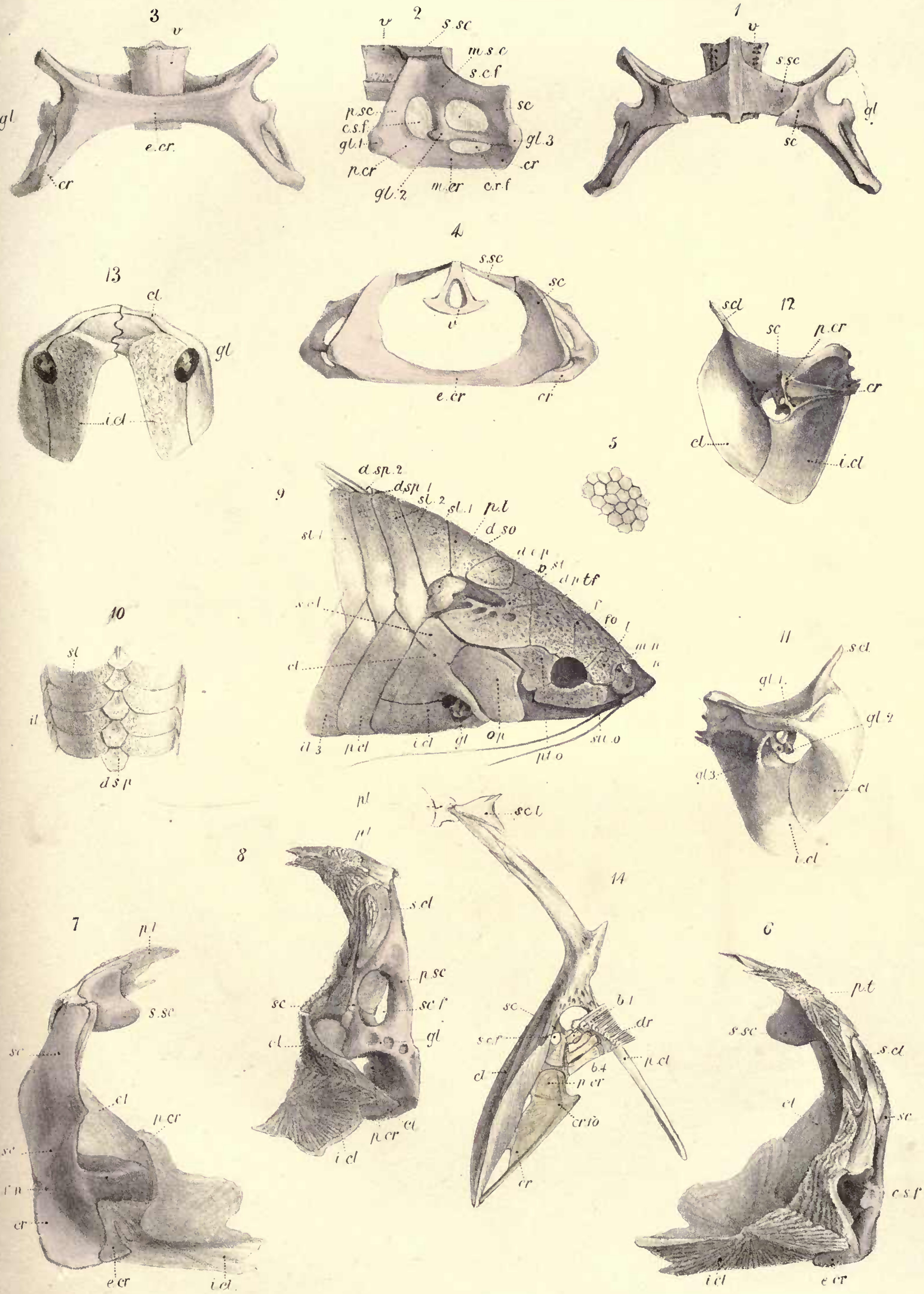
EXPLANATION OF THE PLATES.

PLATE I.

FIG.		SIZE.
1.	*Raia clavata*[1] (half-grown). Shoulder-girdle and part of vertebral column; upper view	nat. size.
2.	Do. do. side view	do.
3.	Do. do. lower view	do.
4.	Do. do. front view	do.
5.	Do. do. part of surface	magnified.
6.	*Acipenser sturio*[2] (half-grown). Left Shoulder-plates; outer side view	$\frac{3}{4}$ nat. size.
7.	Do. do. inner side view	do.
8.	Do. do. posterior view	do.
9.	*Callichthys littoralis*[3] (half-grown). Right shoulder and face	2 diam.
10.	Do. Part of back between the dorsal fins	do.
11.	Do. Shoulder-plates; outer view	do.
12.	Do. do. inner view	do.
13.	Do. do. lower view	do.
14.	*Zeus faber*[4] (middle size). Left Shoulder-plates; outer side	nat. size.

[1] See pp. 6—8. [2] See pp. 10—14. [3] See pp. 23—27. [4] See pp. 50, 51.

Plate I



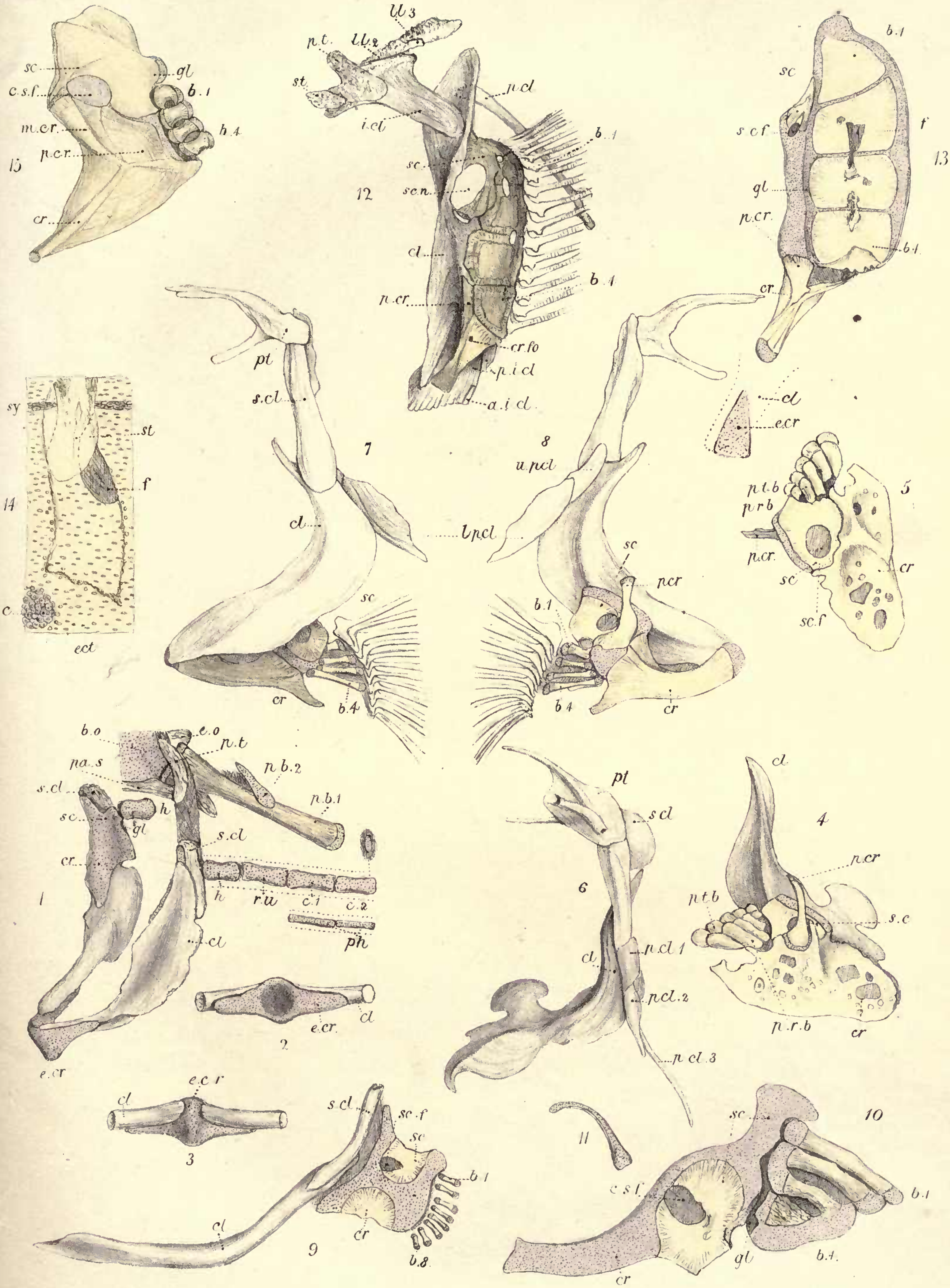
Geo West lith. W.K. Parker & G. West del[t]. M & N Hanhart imp.

1-5 RAIA. 6-8 STURIO 9-13 CALLICHTHYS. 14 ZEUS.

PLATE II.

FIG.			SIZE.
1.	*Lepidosiren annectens*[1] (half-grown).	Shoulder-girdle and part of skull .	3 diam.
2.	Do.	Base of Shoulder-girdle; upper view .	do.
3.	Do.	do. lower view . .	do.
4.	*Clupea harengus*[2] (adult).	Right Shoulder-plates; inner view . .	2 do.
5.	Do.	do. outer view . . .	do.
6.	Do.	Left dermal Shoulder-bones; outer view .	do.
7.	*Salmo fario*[3] (half-grown).	Left Shoulder-plates and fin; outer view .	do.
8.	Do.	do. inner view	do.
9.	*Anguilla acutirostris*[4] (3 inches long).	Left Shoulder-plates; outer view .	20 do.
10.	*Esox lucius*[5] (6 inches long).	Left *inner* Shoulder-plates; outer view .	12 do.
11.	Do.	Section through coraco-scapular plate . .	do.
12.	*Cottus bubalis*[6] (adult).	Left Shoulder-plates; outer view . .	2 do.
13.	*Gobius minutus*[7] (adult).	Left *inner* Shoulder-plates; outer view . .	10 do.
14.	Do.	Part of same (middle). . . .	100 do.
15.	*Morrhua vulgaris*.[8]	Left *inner* Shoulder-plates; outer view . .	$\frac{2}{3}$ nat. size.

[1] See pp. 20—23. [2] See pp. 56, 57. [3] See pp. 55, 56. [4] See p. 54.
[5] See pp. 54, 55. [6] See pp. 43, 44. [7] See pp. 47, 48. [8] See p. 53.



Geo West lith. W.K.Parker delt. M & N Hanhart imp.

1-3 LEPIDOSIREN. 4-6 CLUPEA 7.8 SALMO 9 ANGUILLA 10.11 ESOX.
12 COTTUS 13.14 GOBIUS. 15 MORRHUA.

PLATE III.

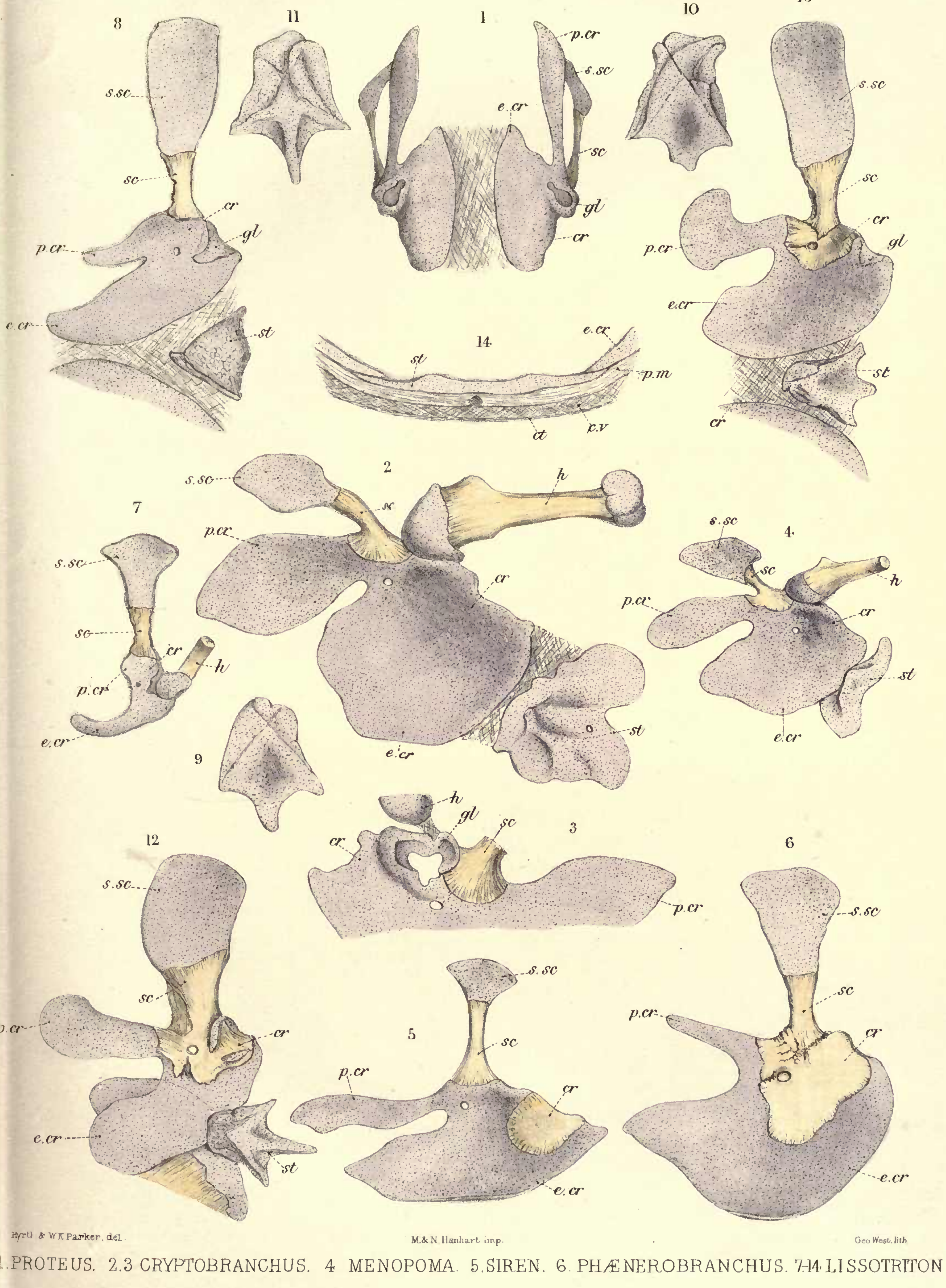
FIG.		SIZE.
1.	*Proteus anguinus*[2] (adult). Shoulder-girdle; lower view . .	4 diam.
2.	*Cryptobranchus japonicus*[3] (adult). Right Shoulder-plate, humerus, and Sternum; inner view. From Hyrtl's figure	nat. size.
3.	Do. do. outer view. From Hyrtl's figure .	do.
4.	*Menopoma alleghaniensis*[4] (young). Inner view of right Shoulder-plate, humerus, and Sternum. From Hyrtl's dissection and figure . . .	2 diam.
5.	*Siren lacertina*[5] (adult female). Right Shoulder-plate; inner view .	do.
6.	*Phænerobranchus mexicanus*[1 and 6] (adult female). Right Shoulder-plate; inner view	3 do.
7.	*Lissotriton punctatus*[7] ($5\frac{1}{2}$ lines long). Left Shoulder-plate and part of humerus; outer view . .	40 do.
8.	Do. (10 lines long). do. and Sternum; outer view	30 do.
9.	Do. (1 inch 2 lines long). Sternum; upper view . .	do.
10.	Do. (adult). Sternum; upper view . . .	12 do.
11.	Do. (do.) do. lower view . . .	do.
12.	Do. (do.) Left and part of right Shoulder-plate and Sternum; outer view . . .	8 do.
13.	Do. (1 inch 8 lines long). Right Shoulder-plate and Sternum; inner view . . .	12 do
14.	Do. (adult). Section through edges of Shoulder-girdle and Sternum .	50 do.

[1] Mr. Mivart informs me that this is merely the Axolotl (*Siredon*) under another name: if so this figure represents a very interesting stage, as the two new bony centres have appeared which show that Hyrtl's specimen was ready to be transformed into *Amblystoma*.

[2] See pp. 58, 59. [3] See pp. 60, 61. [4] See p. 60.

[5] See pp. 61, 62. [6] See p. 62. [7] See pp. 63, 64.

PLATE. 3.



Hyrtl & W.K. Parker, del. M.& N. Hanhart imp. Geo West, lith.

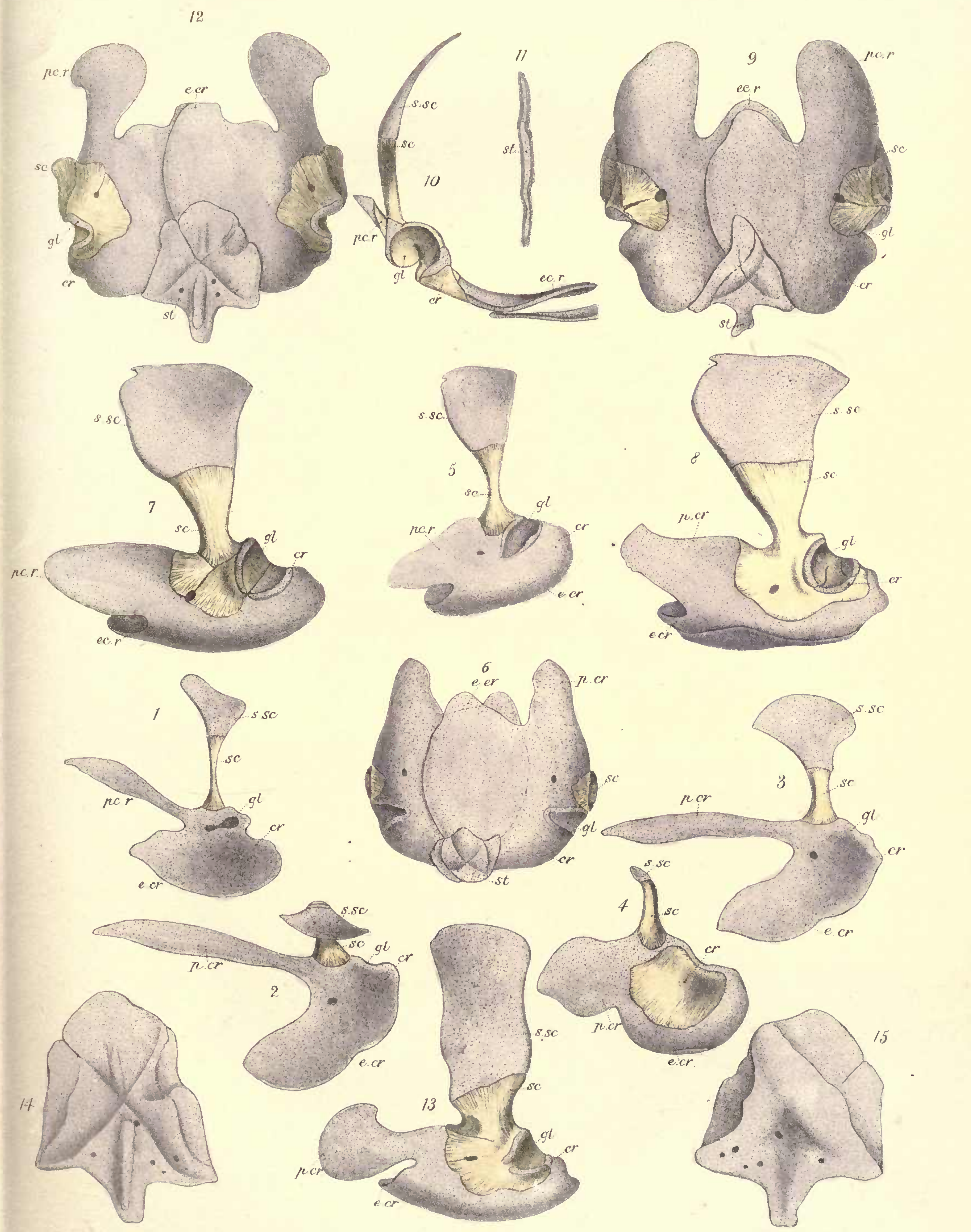
1. PROTEUS. 2.3 CRYPTOBRANCHUS. 4 MENOPOMA. 5. SIREN. 6. PHÆNEROBRANCHUS. 7-14 LISSOTRITON

PLATE IV.

FIG.		SIZE.
1.	*Proteus anguinus*[1] (adult). Left Shoulder-plate; inner view . .	4 diam.
2.	*Menobranchus lateralis*[2] (adult male). Right Shoulder-plate; upper view .	2 do.
3.	Do. do. inner view . . .	do.
4.	*Amphiuma didactylum*.[3] Right Shoulder-plate; inner view. From Hyrtl's dissection and figure . . .	4 do.
5.	*Salamandra maculosa*[4] (1 inch 6 lines long). Shoulder-girdle, outside; side view	12 do.
6.	Do. (do.) do. and Sternum; lower view	do.
7.	Do. (nearly adult). Shoulder-plate, outside; side view . .	5 do.
8.	Do. (old) do. do. . . .	4 do.
9.	Do. (do.) do. and Sternum; lower view . .	do.
10.	Do. (do.) do.; end view . . .	do.
11.	Do. (do.) Section of Sternum . . .	10 do.
12.	*Triton cristatus*[5] (old male). Shoulder-girdle and Sternum; lower view .	6 do.
13.	Do. (do.) Shoulder-plate, outside; side view . .	do.
14.	Do. (do.) Sternum; lower view . . .	9 do.
15.	Do. (do.) do. upper view . . .	do.

[1] See pp. 58, 59. [2] See pp. 59, 60. [3] See p. 62.
[4] See pp. 65, 66. [5] See pp. 64, 65.

Plate IV.



I. PROTEUS. 2. 3. MENOBRANCHUS. 4. AMPHIUMA. 5-II. SALAMANDRA. 12-15. TRITON.

PLATE V.

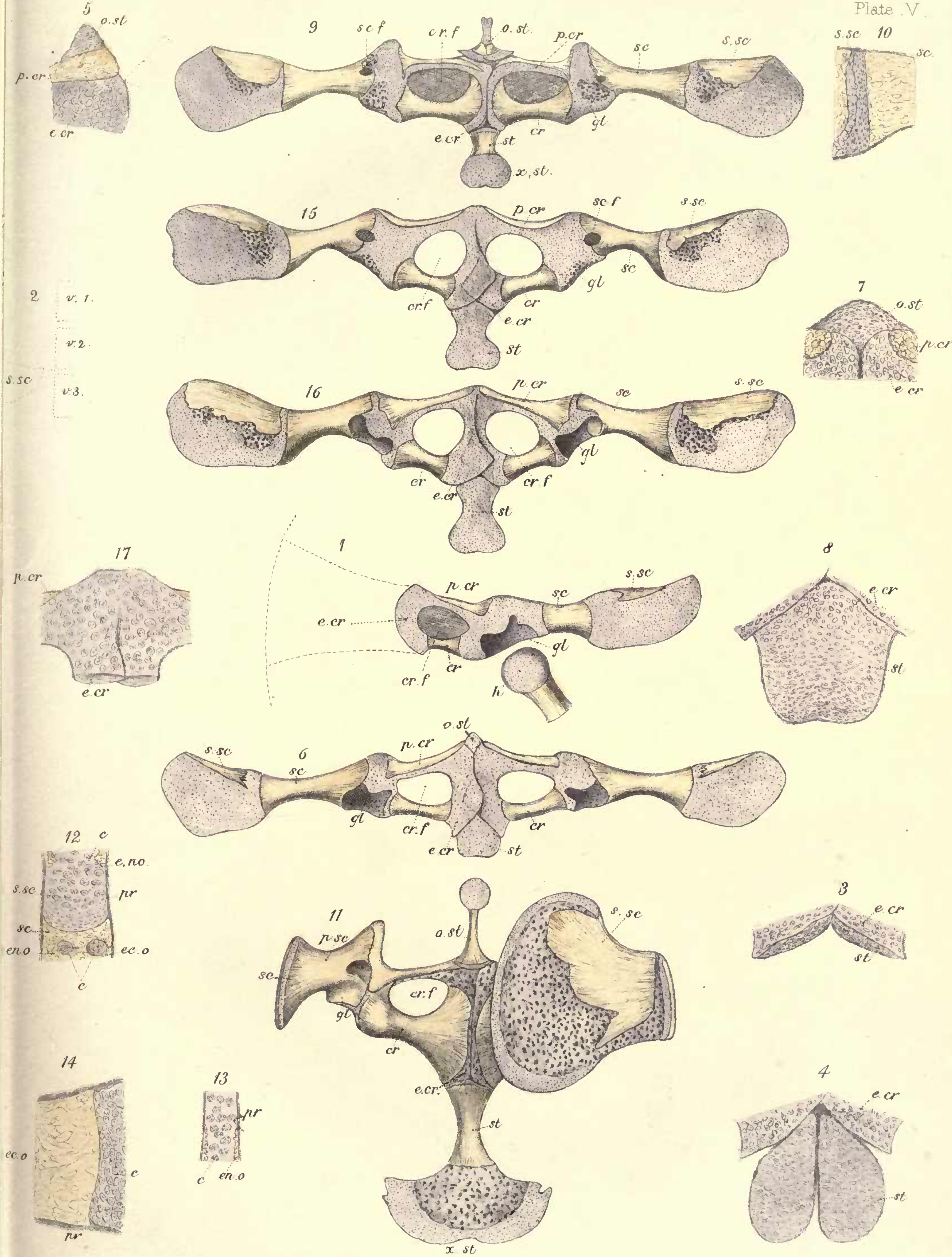
FIG.			SIZE.
1.	*Rana temporaria.*[1]	(Tadpole with budding limbs, but perfect tail). Left Shoulder-plate and head of humerus; outer view	25 diam.
2.	Do.	(do.) diagram to show the relation of Shoulder-blade to vertebræ . .	do.
3.	Do.	(do., with tail half-absorbed). First appearance of Sternum, and part of Shoulder-girdle .	75 do.
4.	Do.	(do. with tail almost absorbed). Sternal moieties and part of epicoracoids . . .	do.
5.	Do	(do.), first separation of omosternum from præcoracoid	do.
6.	Do.	(do. with tail absorbed). Shoulder-girdle and Sternum outspread, and seen from below . .	15 do.
7.	Do.	(do.) omosternum, with united moieties, part of last figure	75 do.
8.	Do.	(do.) Sternum, part of same figure . . .	do.
9.	Do.	(Frog few weeks after metamorphosis). Shoulder-girdle and Sternum, outspread and seen from above	7 do.
10.	Do.	(do.) part of same, showing continuity of cartilage between scapula and supra-scapula .	25 do.
11.	Do.	(Old male Frog). Shoulder-girdle (with left supra-scapula removed)[2] and Sternum; upper view .	4 do.
12.	Do.	(do.) section through scapulo-suprascapular synchondrosis	25 do.
13.	Do.	(do.) section through upper part of supra-scapula .	do.
14.	Do.	(same as fig. 1). Upper edge of scapula, showing absence of cleft	100 do.
15.	*Bufo vulgaris*[3] (1st summer).	Shoulder-girdle and Sternum outspread, and seen from above . . .	7 do.
16.	Do.	(do.) do. lower view . . .	do.
17.	Do.	(do.) part of fig. 15, showing coalescence of epicoracoids . .	25 do.

[1] See pages 79—83.

[2] In many of the figures (upper views) of the Shoulder-girdle of the Anoura I have not drawn the left supra-scapula.

[3] See page 72.

Plate V.



Geo West lith. W.K. Parker del^t. M & N Hanhart imp.

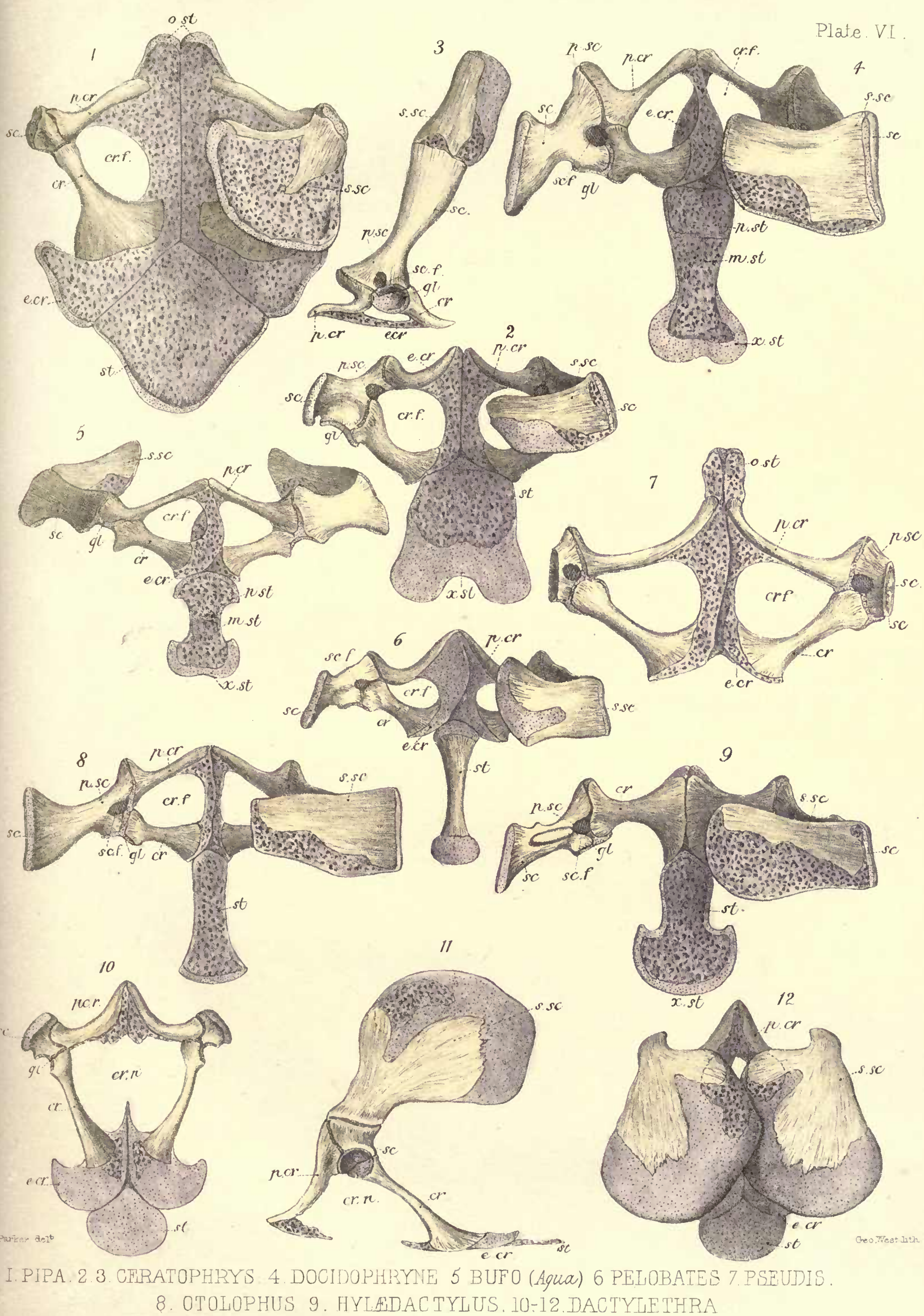
I-14. RANA TEMPORARIA 15-17. BUFO VULGARIS.

PLATE VI.

FIG.		SIZE.
1.	*Pipa dorsigera*[1] (adult female). Shoulder-girdle and Sternum; upper view .	nat. size.
2.	*Ceratophrys dorsata*[2] (adult male). Do.	do.
3.	Do. (do.) Left moiety of Shoulder-girdle; outer view .	do.
4.	*Docidophryne gigantea*[3] (adult female) Do.	do.
5.	*Bufo agua*[4] (old). Shoulder-girdle and Sternum; lower view . .	do.
6.	*Pelobates fuscus*[5] (adult male). Do. upper view	3 diam.
7.	*Pseudis paradoxa*[6] (do.) Part of Shoulder-girdle; upper view . .	4 do.
8.	*Otolophus margaritiferus*[7] (adult female). Shoulder-girdle and Sternum; upper view . . .	3 do.
9.	*Hylædactylus celebensis*[8] (young male). Do.	do.
10.	*Dactylethra capensis*[9] (adult female). Do. with both suprascapulæ absent .	2 do.
11.	Do. Left Shoulder-plates and Sternum; outer view .	do.
12.	Do. Perfect Shoulder-girdle and Sternum; upper view .	do.

[1] See pp. 73—75. [2] See p. 70. [3] See pp. 70, 71. [4] See p. 71. [5] See pp. 71, 72.
[6] See p. 75. [7] See p. 71. [8] See pp. 67, 68. [9] See pp. 68, 69.

Plate. VI.



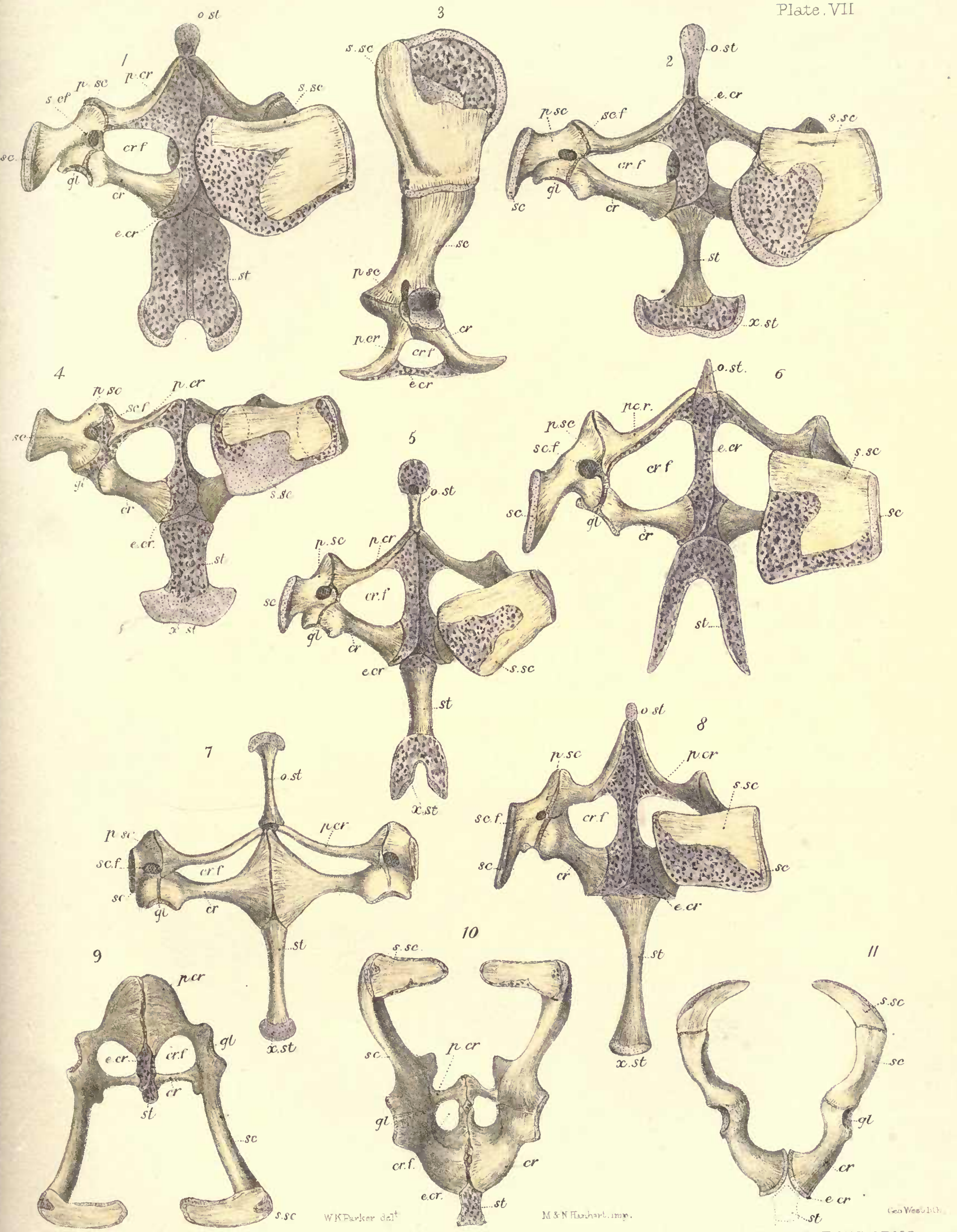
W K Parker del.t Geo. West lith.

I. PIPA. 2. 3. CERATOPHRYS. 4. DOCIDOPHRYNE. 5. BUFO (*Agua*) 6. PELOBATES. 7. PSEUDIS.
8. OTOLOPHUS. 9. HYLÆDACTYLUS. 10-12. DACTYLETHRA.

PLATE VII.

FIG.		SIZE.
1.	*Acrodytes Daudinii*[1] (adult female). Shoulder-girdle and Sternum; upper view	4 diam.
2.	*Cystignathus pachypus*[2] (adult male). Do. do. . .	3 do.
3.	Do. Left Shoulder-plates; outer view . .	do.
4.	*Bufo vulgaris*[3] (half-grown). Shoulder-girdle and Sternum; upper view .	4 do.
5.	*Pleurodema Bibronii*[4] (young female). Do. do. . .	do.
6.	*Calamites cyaneus*[5] (adult male). Do. do. . .	3 do.
7.	*Plectropus pictus*[6] (young female). Do. (part) do. . .	6 do.
8.	*Megalophrys montana*[7] (young male). Do. do. . .	4 do.
9.	*Systoma gibbosum*[8] (adult male). Do. as seen antero-superiorly .	do.
10.	*Systoma granosum*[9] (adult female). Do. as seen postero-superiorly .	3 do.
11.	*Microps oxyrhynchus*[10] (young female). Shoulder-girdle as seen antero-inferiorly	4 do.

[1] See pp. 75, 76. [2] See pp. 76, 77. [3] See p. 72. [4] See p. 77. [5] See p. 76.
[6] See pp. 77, 78. [7] See p. 78. [8] See p. 69. [9] See pp. 69, 70. [10] See p. 67.

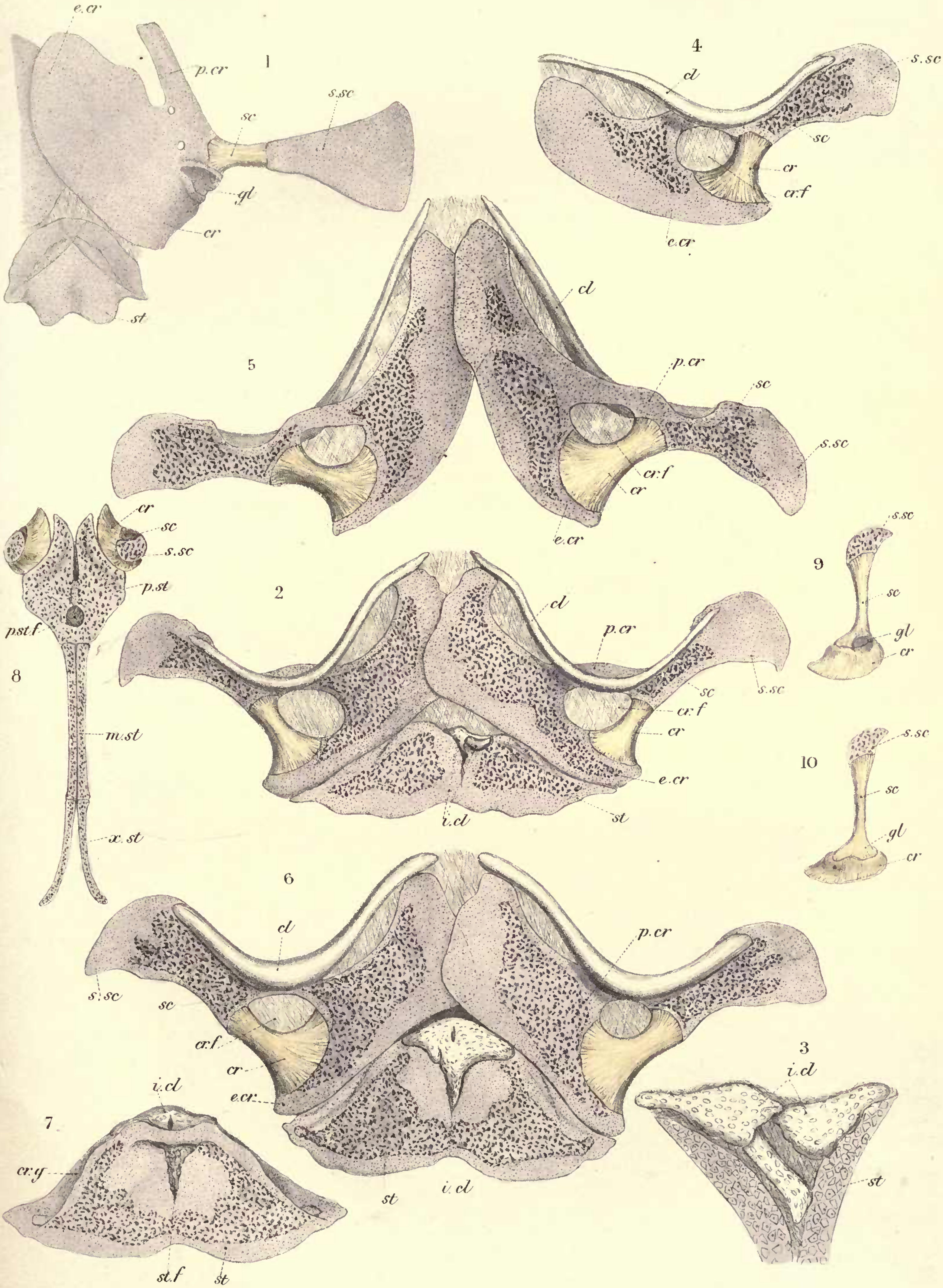


1. ACRODYTES. 2,3. CYSTIGNATHUS 4. BUFO (*Vulgaris*) 5. PLEURODEMA. 6. CALAMITES 7. PLECTROPUS
8. MEGALOPHRYS 9. SYSTOMA (*Gibbosum*) 10. SYSTOMA (*Granosum*) 11. MICROPS

PLATE VIII.

FIG.		SIZE.
1.	*Siredon pisciformis*[1] (large specimen). Left and part of right Shoulder-plate and Sternum outspread; lower view .	3 diam.
2.	*Anguis fragilis*[2] (3 inches long). Shoulder-girdle and Sternum outspread; lower view . . .	25 do.
3.	Do. part of the same	125 do.
4.	Do. (3 inches 10½ lines long). Left Shoulder-plate; outer view .	25 do.
5.	Do. (nearly adult). Shoulder-plates; upper view . .	15 do.
6.	Do. (old) do. and Sternum; lower view .	12 do.
7.	Do. (do.) Sternum; upper view . . .	do.
8.	*Chirotes canaliculatus*[3] (adult male). Shoulder-girdle and Sternum; upper view . . .	9 do.
9.	Do. Left Shoulder-plate; outer view . .	do.
10.	Do. Right do.; inner view . . .	do.

[1] See p. 61. [2] See pp. 97—100. [3] See pp. 95—97.



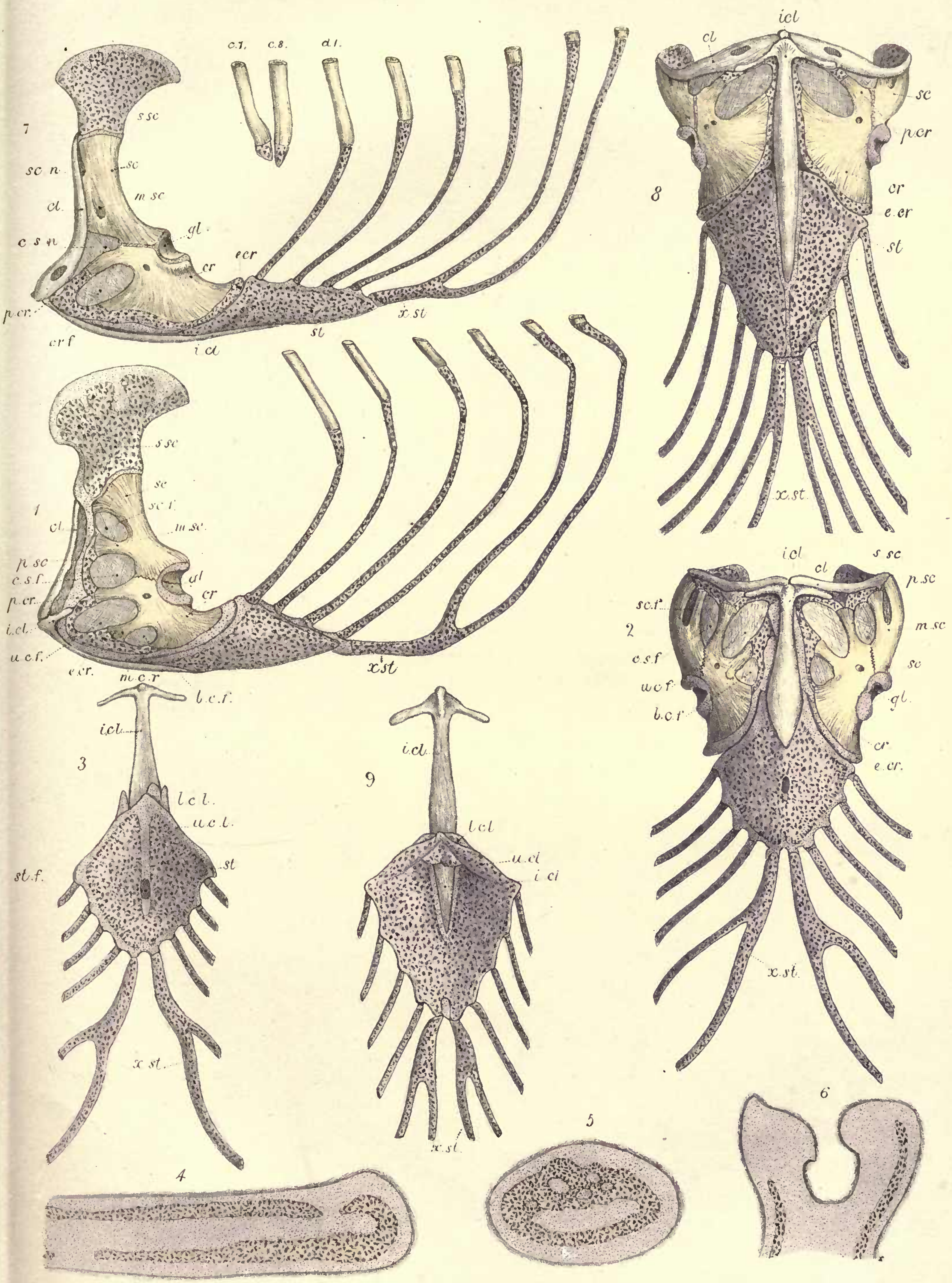
W.K.Parker F.R.S. del. M.&N. Hanhart imp. Geo. West lith.

1 SIREDON. 2-7 ANGUIS. 8-10. CHIROTES.

PLATE IX.

FIG.			SIZE.
1.	*Iguana tuberculata*[1] (adult).	Left Shoulder-plate and Sternum; outer view .	nat. size.
2.	Do.	Shoulder-girdle and Sternum; lower view .	do.
3.	Do.	Sternum and interclavicle; upper view .	do.
4.	Do.	Transversely vertical section of Sternum .	12 diam.
5.	Do.	Transverse section of xiphisternal horn .	do.
6.	Do.	Vertical section through coracoid grooves .	do.
7.	*Læmanctus*[2] *longipes* (adult).	Left Shoulder-plate and Sternum; outer view .	3 do.
8.	Do.	Shoulder-girdle and Sternum; lower view .	do.
9.	Do.	Sternum and interclavicle; upper view .	do.

[1] See pp. 107—110. [2] See pp. 110, 111.



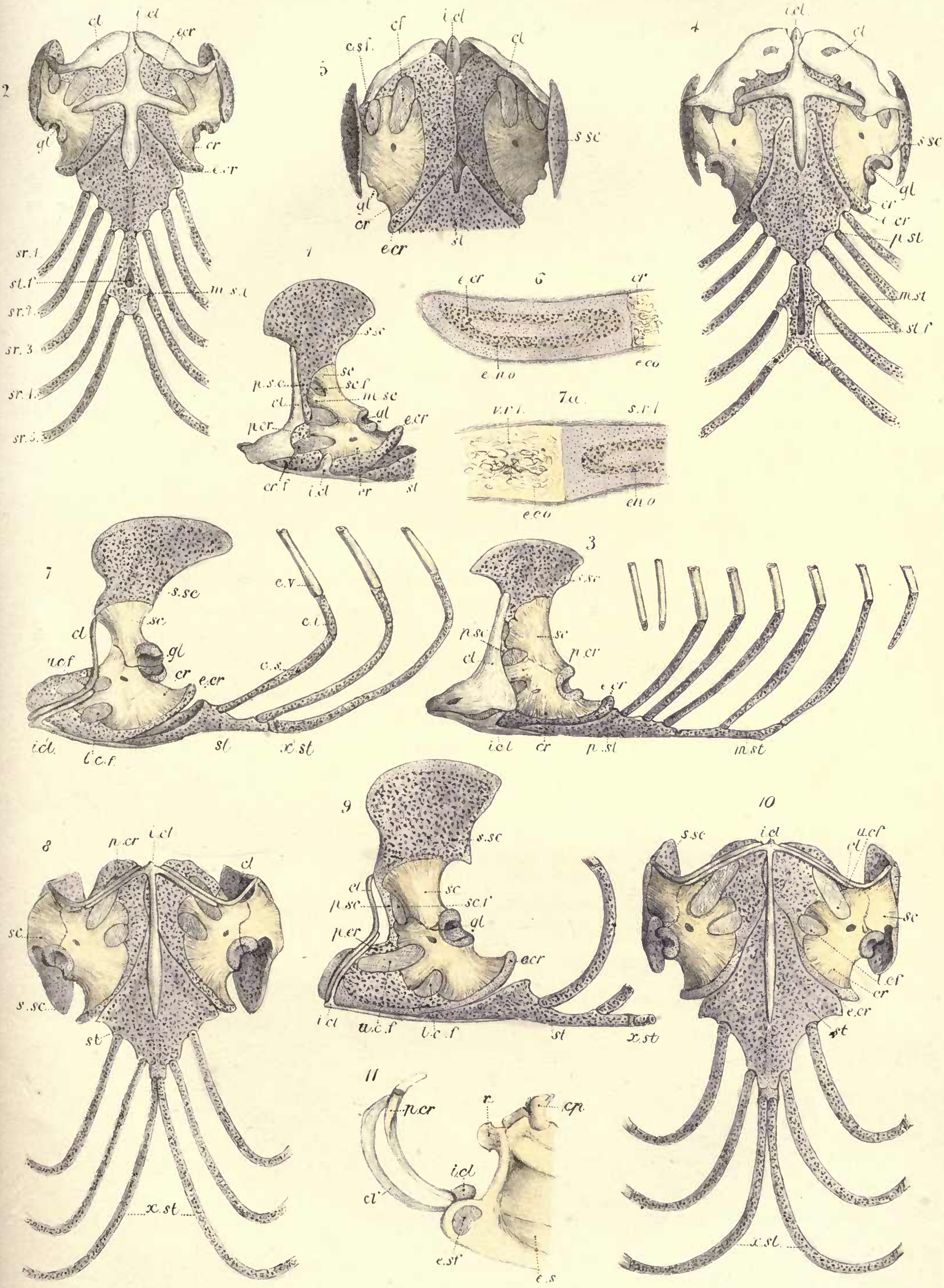
Geo West lith. W.K. Parker del. M & N Hanhart imp.

I-6 IGUANA. 7–9 LÆMANCTUS.

PLATE X.

FIG.			SIZE.
1.	*Cyclodus nigroluteus*[1] (adult).	Left Shoulder-plate and part of Sternum; outer view . . .	$1\frac{1}{2}$ diam.
2.	Do.	Shoulder-girdle and Sternum; lower view .	do.
3.	*Trachydosaurus rugosus*[2] (adult).	Left Shoulder-plate and Sternum; outer view . . .	do.
4.	Do.	Shoulder-girdle and Sternum; lower view .	do.
5.	Do.	do. and part of Sternum; upper view	do.
6.	*Cyclodus nigroluteus*[3] (adult).	Section of lower edge of Shoulder-plate .	10 do.
7.	*Psammosaurus scincus*[4] (adult).	Left Shoulder-plate and Sternum; outer view	$1\frac{1}{8}$ do.
7*a*.	Do.	Section of first rib	6 do.
8.	Do.	Shoulder-girdle and Sternum; lower view .	$1\frac{1}{8}$ do.
9.	*Monitor dracæna*[5] (15 inches long).	Left Shoulder-plate and Sternum; outer view .	3 do.
10.	Do.	Shoulder-girdle and Sternum; lower view .	3 do.
11.	*Thalasseus poliocercus*[6] (adult).	Furcula and fore-part of Sternum . .	nat. size.

[1] See pp. 111—113.
[2] See pp. 113, 114.
[3] See pp. 111—113.
[4] See pp. 114—116.
[5] See pp. 116, 117.
[6] See p. 155.



Geo. West Lith. W. K. Parker del. M & N. Hanhart imp.

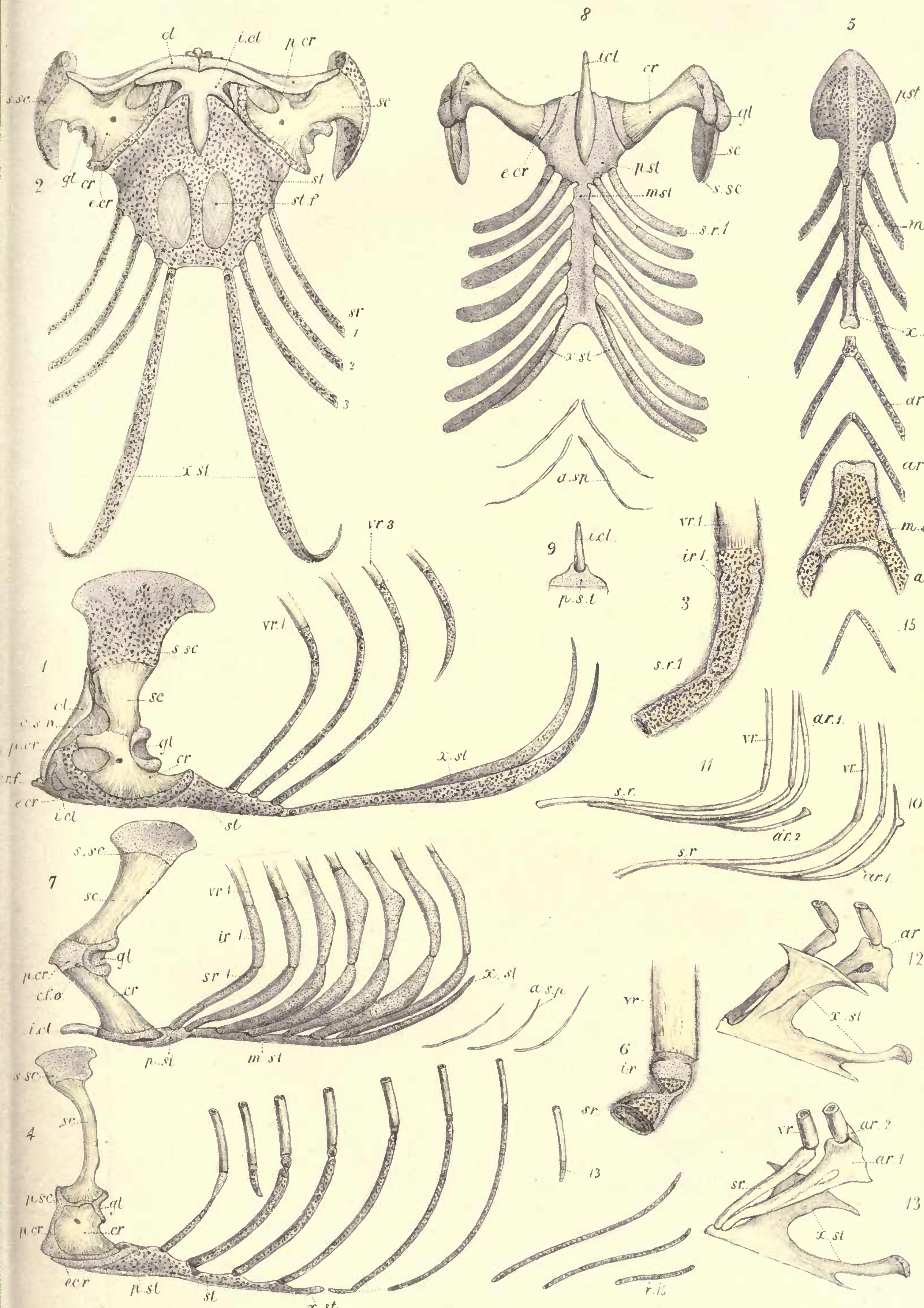
1 2 & 6 CYCLODUS. 3-5 TRACHYDOSAURUS. 7. 7a 8 PSAMMOSAURUS 9.10 MONITOR. 11 THALASSEUS

PLATE XI.

FIG.			SIZE.
1.	*Stellio cordylinus*[1] (adult).	Left Shoulder-plate and Sternum; outer view	$2\frac{2}{3}$ diam.
2.	Do.	Shoulder-girdle and Sternum; lower view .	do.
3.	Do.	Second rib, at the joints; side view .	8 do.
4.	*Chamæleo vulgaris*[2] (adult).	Left Shoulder-plate and Sternum; outer view	2 do.
5.	Do.	Sternum; lower view . .	2 and 8 do.
6.	Do.	First dorsal rib, at the joints; side view .	8 do.
7.	*Crocodilus acutus*[3] (ripe embryo).	Left Shoulder-plate and Sternum; outer view	$2\frac{1}{3}$ do.
8.	Do.	Shoulder-girdle and Sternum; lower view .	do.
9.	Do.	Fore part of Sternum and inter-clavicle; upper view . . .	do.
10.	*Podiceps rubricollis*[4] (adult).	Sternal and abdominal ribs, right side; inner view	nat. size.
11.	Do.	do. left side; outer view .	do.
12	*Talegalla Lathami*[5] (adult).	Left xiphisternum, sternal and abdominal ribs; outer view . . .	$\frac{2}{3}$ do.
13.	Do.	Right do. inner view .	do.

[1] See pp. 119—121. [2] See pp. 122—124. [3] See pp. 131, 132.
[4] See p. 149. [5] See p. 185.

Plate XI



Geo West lith. W.K. Parker delt. M&N Hanhart imp.

1-3 STELLIO. 4-6 CHAMÆLEO. 7-9 CROCODILUS. 10.11 PODICEPS. 12.13 TALEGALLA.

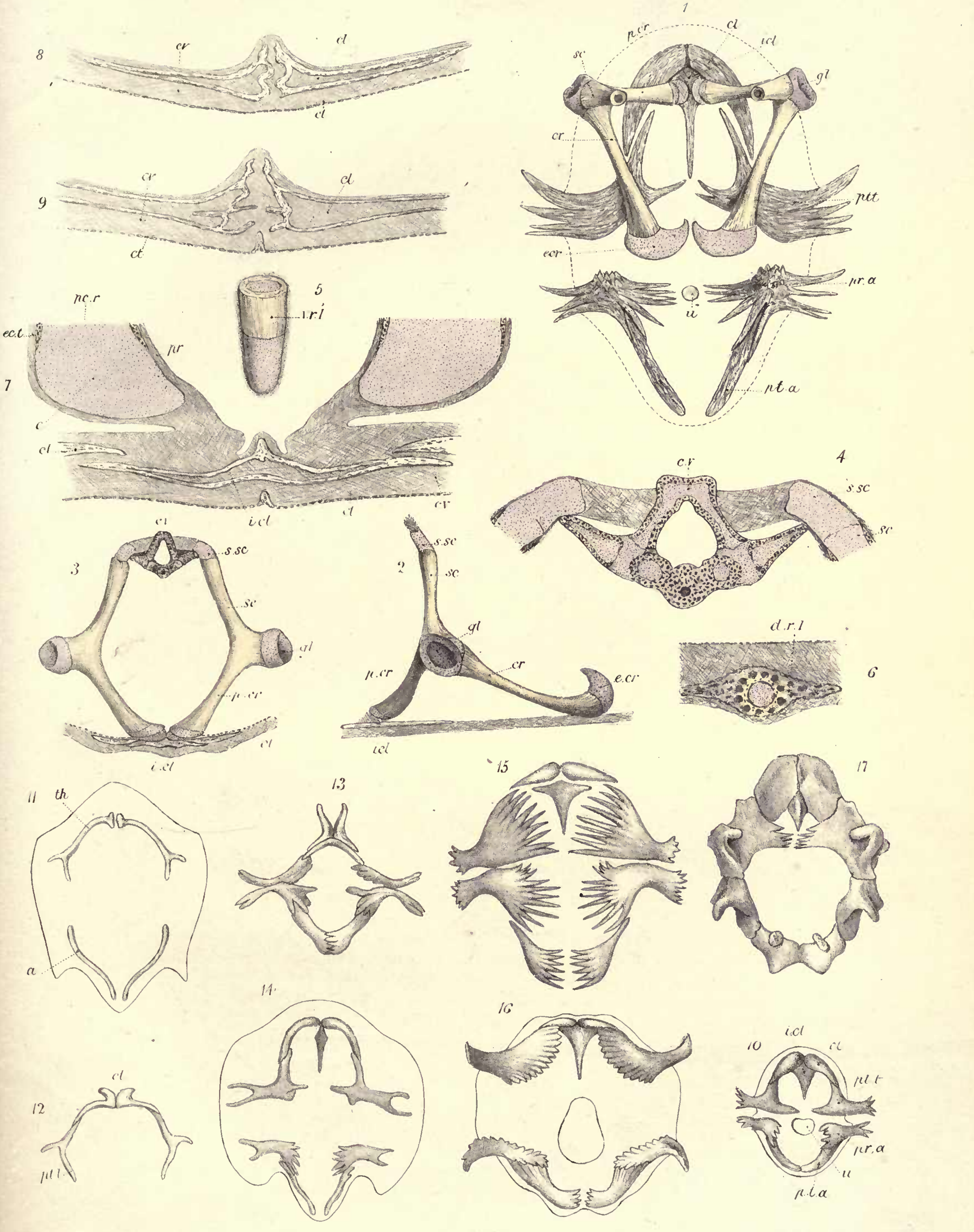
PLATE XII.

FIG.				SIZE.
1.	*Chelone mydas*[1]	(a few days old).	Shoulder-girdle (with upper part of scapulæ removed) and plastron; upper view .	2 diam.
2.	Do.	(do.)	Left Shoulder-bars, and part of plastron; outer view	do.
3.	Do.	(do.)	Shoulder-girdle and tenth vertebra; front view . . .	do.
4.	Do.	(do.)	part of fig. 3	6 do.
5.	Do.	(do.)	lower part of third long rib . .	do.
6.	Do.	(do.)	section of a dorsal rib . .	10 do.
7.	Do.	(do.)	section through base of coracoids, and contiguous part of Plastron . .	do.
8.	Do.	(do.)	transversely vertical section through fore-part of Plastron . . .	do.
9.	Do.	(do.)	do. through Plastron a little further back	do.
10.	Do.	(earlier stage), Plastron; upper view.		From Rathke.
11.	*Sphargis coraiacea*[2]	(young). Plastron; upper view.		From Rathke.
12.	Do.	(a somewhat older specimen). Fore-part of Plastron; upper view.		From Rathke.
13.	*Trionyx gangeticus*[3]	(young). Plastron; upper view.		From Rathke.
14.	*Chelonia*[4] *virgata*[5]	(embryo). Plastron; upper view.		From Rathke.
15.	*Emys Europæa*[6]	(young). Plastron; upper view.		From Rathke.
16.	*Testudo*——?[7]	(embryo). Plastron; upper view.		From Rathke.
17.	*Platemys*——?[8]	(young). Plastron; upper view.		From Rathke.

[1] See pp. 133—141. [2] See p. 134. [3] See p. 135.

[4] Rathke uses Brongniart's generic term, *Chelonia;* I prefer its synonym *Chelone;* as the former term is often employed to signify the whole group of the Testudinata.

[5] See p. 134. [6] See p. 135. [7] See p. 135. [8] See p. 135.



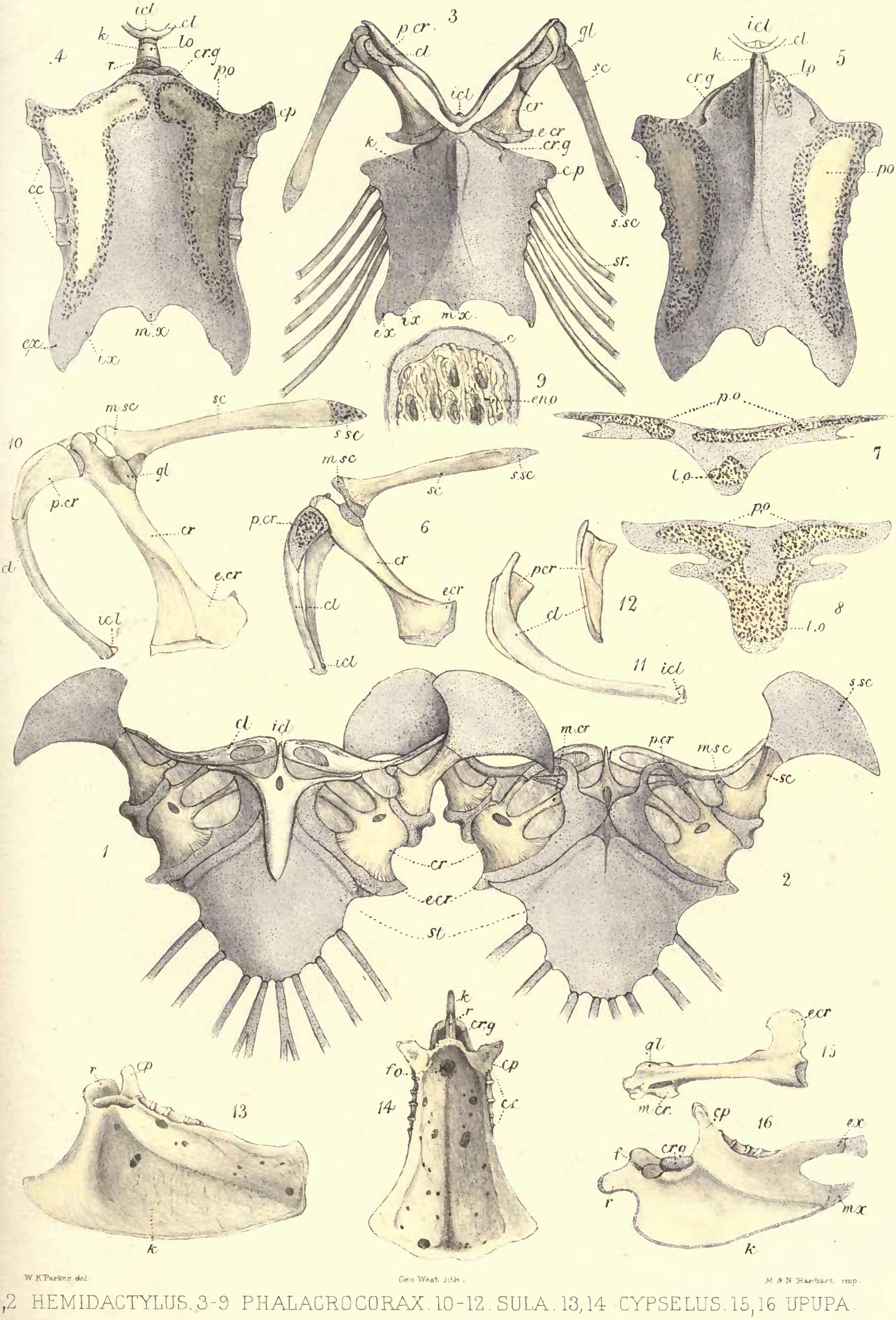
Geo West lith. Rathke & W K Parker del. M & N Hanhart imp.

1-10 CHELONIA (*mydas*) 11.12 SPHARCIS. 13 TRIONYX. 14 CHELONIA (*virgata*) 15 EMYS. 16 TESTUDO. 17 PLATEMYS.

PLATE XIII.

FIG.				SIZE.
1.	*Hemidactylus*[1] ——?	(1 inch long).	Shoulder-girdle and Sternum; lower view	15 diam.
2.	Do.	(do.)	do. upper view	do.
3.	*Phalacrocorax*[2]——?	(young squab).	Shoulder-girdle and Sternum; lower view . . .	nat. size.
4.	Do.	(older squab).	Sternum; upper view . .	$\frac{3}{4}$ do.
5.	Do.	(do.)	do. lower view . .	do.
6.	Do.	(do.)	Shoulder-girdle; side view .	do.
7.	Do.	(do.)	Section of Sternum through coracoid grooves . . .	2 diam.
8.	Do.	(do.)	do. nearer to front end	do.
9.	Do.	(do.)	Section of præ-coracoid . .	3 do.
10.	*Sula fusca*[3]	(fledgling).	Shoulder-girdle; side view .	$\frac{3}{4}$ nat. size.
11.	Do.	(do.)	Right furcular ramus; inner view .	do.
12.	Do.	(do.)	do. front view .	do.
13.	*Cypselus apus*[4]	(first summer).	Sternum; side view . .	2 diam.
14.	Do.	(do).	do. upper view . .	do.
15.	*Upupa epops*[5]	(fledgling).	Coracoid; front view . .	do.
16.	Do.	(do.)	Sternum; side view . .	do.

[1] See pp. 117—119. [2] See pp. 149, 150. [3] See pp. 150, 151.
[4] See pp. 176, 177. [5] See pp. 174, 175.



W K Parker del. Geo West lith. M & N Hanhart imp.

1,2 HEMIDACTYLUS. 3-9 PHALACROCORAX. 10-12. SULA. 13,14 CYPSELUS. 15,16 UPUPA.

PLATE XIV.

FIG.				SIZE.
1.	*Eudyptes chrysocome*[1]?	(large squab).	Shoulder-girdle and Sternum; side view	$\frac{3}{4}$ nat. size.
2.	Do.	(do.)	Lower part of furcula . .	$1\frac{1}{2}$ diam.
3.	Do.	(do.)	Front part of Sternum; upper view .	nat. size.
4.	*Podiceps europæus*[2]	(adult.)	Sternum; upper view . .	do.
5.	Do.	(do.)	do. side view . .	do.
6.	*Grus montignesia*[3]	(newly hatched).	Shoulder-girdle and Sternum; lower view	$1\frac{1}{2}$ diam.
7.	Do.	(do.)	Sternum; side view . .	do.
8.	Do.	(do.)	do. fore part; upper view .	do.
9.	*Psophia crepitans*[4]	(adult).	Scapula and coracoid; outer view .	nat. size.
10.	*Ardea purpurea*[5]	(first summer).	Furcula; oblique view . .	do.
11.	*Dicholophus cristatus*[6]	(adult). .	Shoulder-girdle and Sternum; side view	$\frac{3}{4}$ do.
12.	Do.	(do.)	Sternum; hinder part; upper view .	do.
13.	*Ulula aluco*[7]	(adult).	Sternum; upper view . .	nat. size.
14.	Do.	(do.)	do. side view . .	do.
15.	*Agapornis pullaria*[8]	(adult).	Shoulder-girdle and Sternum; side view	$1\frac{1}{2}$ diam.
16.	*Psittacus erythacus*[9]	(adult).	Furcula; front view . .	nat. size.
17.	Do.	(do.)	do. oblique view . .	do.
18.	*Ramphastos toco*[10]	(adult).	Shoulder-girdle and Sternum; side view	do.
19.	Do.	(do.)	Sternum; upper view . .	do.
20.	Do.	(do.)	Left Shoulder-girdle moiety; upper view	do.
21.	*Picus viridis*[11]	(adult).	Shoulder-girdle; side view .	do.
22.	*Galbula* ———[12]?	(adult).	Sternum; lower view . .	2 diam.
23.	Do.	(do.)	do. side view . .	do.

[1] See pp. 145, 146.
[2] See pp. 148, 149.
[3] See pp. 158—160.
[4] See pp. 158—160.
[5] See pp. 163, 164.
[6] See pp. 166—169.
[7] See pp. 166—169.
[8] See pp. 169, 170.
[9] See pp. 169, 170.
[10] See p. 171.
[11] See p. 171.
[12] See p. 174.

WK Parker & G West del[t]

M & N Hanhart imp

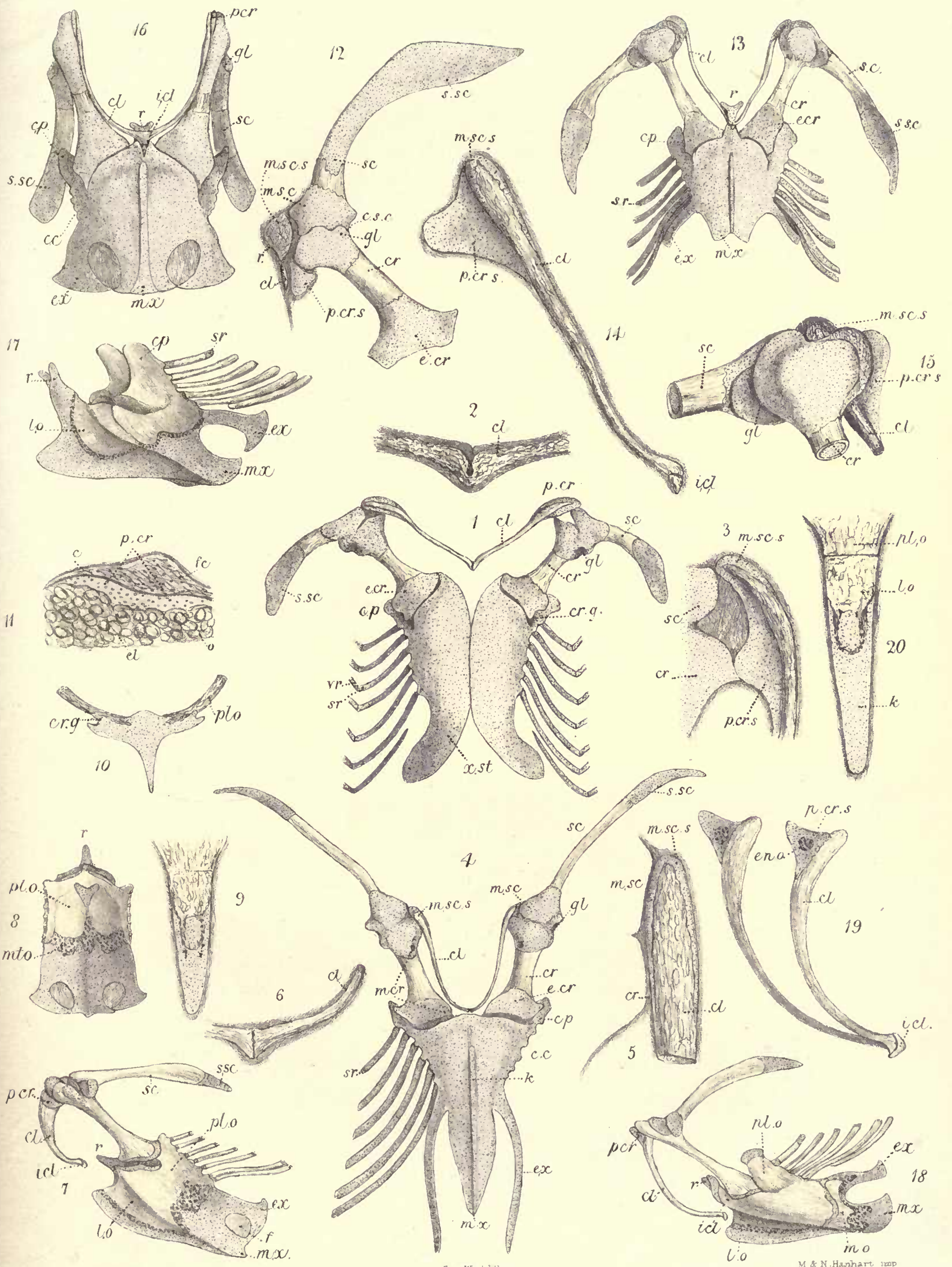
1-3 EUDYPTES. 4,5 PODICEPS. 6-8 GRUS. 9 PSOPHIA, 10 ARDEA, 11,12 DICHOLOPHUS. 13,14 ULULA, 15 AGAPORNIS. 16,17 PSITTACUS, 18-20 RAMPHASTOS. 21 PICUS. 22,23 GALBULA.

PLATE XV.

FIG.		SIZE.
1.	*Vanellus cristatus*[1] (one-third of incubating period). Shoulder-girdle and Sternum; lower view . .	7 diam.
2.	Do. lower end of clavicles	20 do.
3.	Do. junction of clavicle with coracoid and acromion .	do.
4.	*Gallinula chloropus*[2] (half of incubating period). Shoulder-girdle and Sternum; lower view . . .	6 do.
5.	Do. junction of clavicle with coracoid and acromion .	15 do.
6.	Do. lower end of clavicles	do.
7.	*Nisus communis*[3] (half-fledged). Shoulder-girdle and Sternum; side view .	nat. size.
8.	Do. do. Sternum; upper view . .	do.
9.	Do. do. Section of sternal keel . .	7 diam.
10.	Do. do. do. through coracoid grooves .	2 do.
11.	Do. do. do. præ-coracoid and clavicle .	10 do.
12.	*Linota cannabina*[4] (two-fifths of incubating period). Right Shoulder-plates; inner view . . .	20 do.
13.	Do. (four-fifths of incubating period). Shoulder-girdle and Sternum; lower view . .	8 do.
14.	Do. (do.) Right clavicle and cartilage-segments; inner view	24 do.
15.	Do. (do.) Junction of clavicle with coracoid and scapula; outer view . . .	do.
16.	*Merula vulgaris*[5] (four-fifths of incubating period). Shoulder-girdle and Sternum; lower view . .	10 do.
17.	Do. (fledgling). Sternum; side view . .	2 do.
18.	*Corvus monedula*[6] (newly-fledged). Shoulder-girdle and sternum; outer view .	nat. size.
19.	Do. (do.) Furcula; side view . . .	2 diam.
20.	Do. (do.) Section of sternal keel . .	10 do.

[1] See pp. 155—157.
[2] See pp. 161, 162.
[3] See pp. 166—169.
[4] See pp. 178—181.
[5] See pp. 178—181.
[6] See pp. 178—181.

Plate XV.



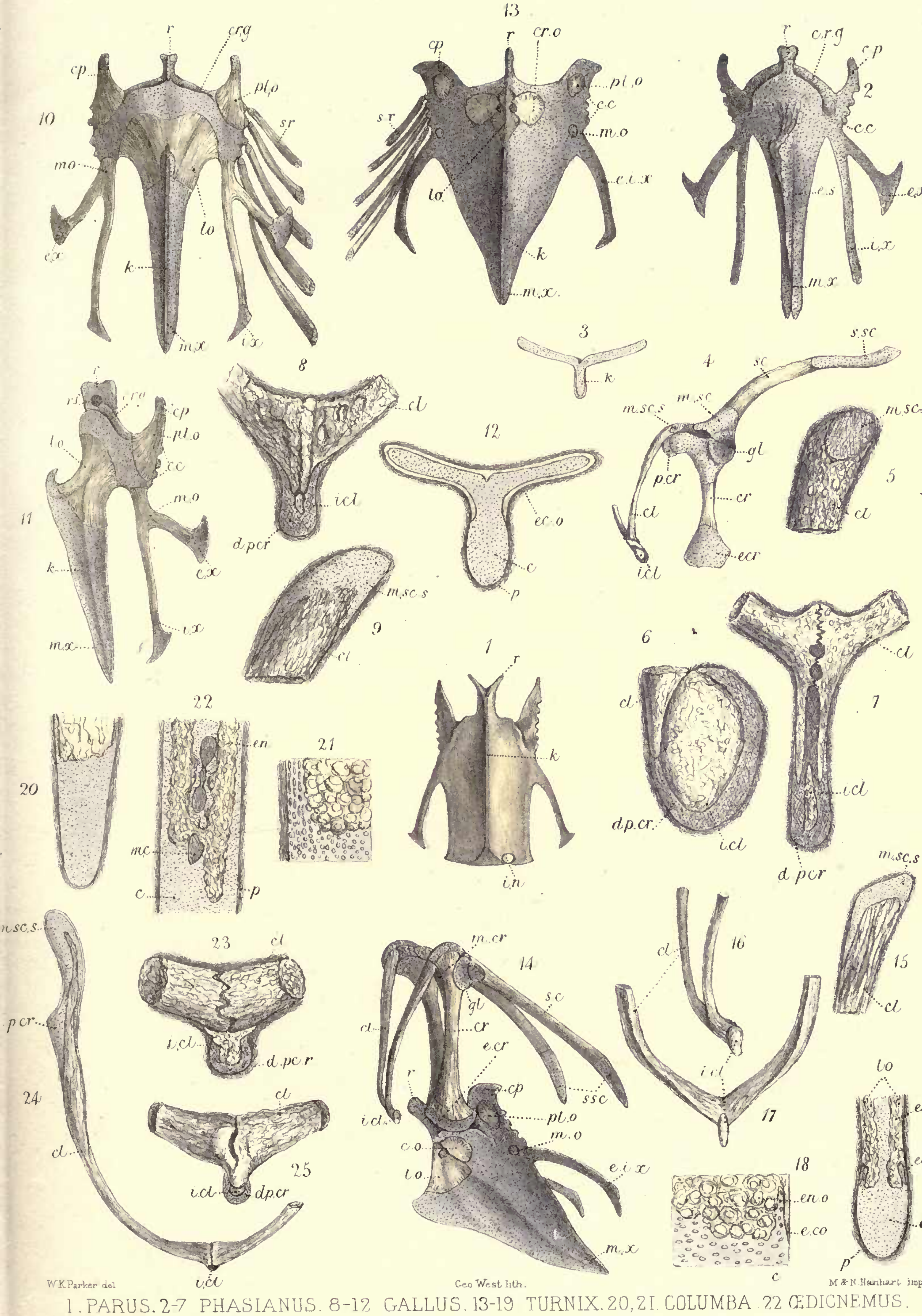
W K Parker del^t. Geo West lith M & N Hanhart imp

1-3 VANELLUS. 4-6. GALLINULA. 7-11 NISUS. 12-15 LINOTA. 16-17 MERULA. 18-20. CORVUS.

PLATE XVI.

FIG.				SIZE.
1.	*Parus cerulæus*[1]	(adult).	Sternum; lower view .	3 diam.
2.	*Phasianus colchicus*[2]	(9 days incubation).	Sternum; lower view .	6 do.
3.	Do.	(do.)	Section of fore part of sternal keel . .	24 diam.
4.	Do.	(do.)	Left Shoulder-plate; outer view	6 do.
5.	Do.	(do.)	Head of clavicle, with cartilage-segment . .	40 do.
6.	Do.	(do.)	Base of clavicle, with interclavicle, and fibro-cartilaginous rim; side view .	do.
7.	Do.	(do.)	do. front view .	do.
8.	*Gallus domesticus*[3]	(10 days incubation).	Base of clavicles, with interclavicle and fibro-cartilage; front view . .	20 do.
9.	Do.	(do.)	Head of clavicle, with cartilage-segment; side view .	do.
10.	Do.	(3 days old).	Sternum; lower view .	3 do.
11.	Do.	(do.)	do. side view .	do.
12.	Do.	(do.)	Section of sternal keel .	10 do.
13.	*Turnix rostratus*[4]	(1 or 2 weeks old).	Sternum; lower view .	4 do.
14.	Do.	(do.)	Shoulder-girdle and Sternum; side view . .	do.
15.	Do.	(do.)	Upper part of clavicle and cartilage-segment; side view .	10 do.
16.	Do.	(do.)	Lower part of furcula; side view	do.
17.	Do.	(do.)	do. hinder view	do.
18.	Do.	(do.)	Section of sternal keel .	100 do.
19.	Do.	(do.)	do. . .	20 do.
20.	*Columba livia*[5]	(3 weeks old).	do. . .	8 do.
21.	Do.	(do.)	do. . .	100 do.
22.	*Œdicnemus crepitans*[6]	(a month old).	do. . .	20 do.
23.	*Uria troile*[7]	(middle of incubating period).	Lower part of furcula; hinder view	do.
24.	*Larus argentatus*[8]	(do.)	Furcula; front view .	10 do.
25.	Do.	(do.)	do. lower part .	30 do.

[1] See p. 181. [2] See pp, 182—184. [3] See pp. 182—184. [4] See pp. 184—186.
[5] See p. 186. [6] See p. 157. [7] See pp. 146—148. [8] See p. 155.



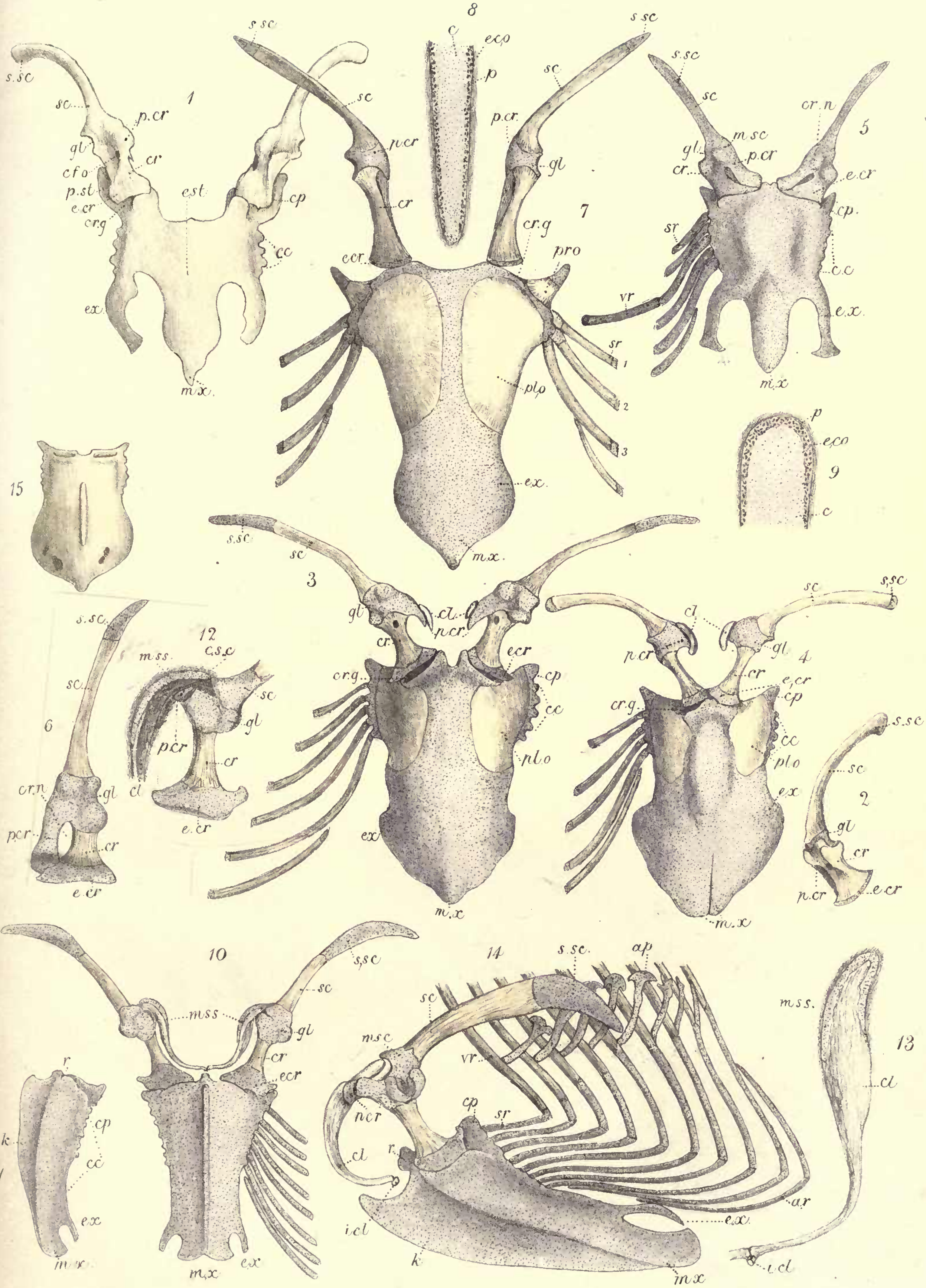
W.K.Parker del. Geo West lith. M & N Hanhart imp

1. PARUS. 2-7 PHASIANUS. 8-12 GALLUS. 13-19 TURNIX. 20,21 COLUMBA. 22 ŒDICNEMUS. 23 URIA. 24, 25 LARUS.

PLATE XVII.

FIG.		SIZE.
1.	*Apteryx australis*[1] (adult). Shoulder-girdle and Sternum; lower view .	$\frac{2}{3}$ nat. size.
2.	Do. (half-grown). Scapula and coracoid; outer view .	nat. size.
3.	*Casuarius Bennettii*[2] (ripe chick). Shoulder-girdle and Sternum; lower view . . .	$1\frac{1}{2}$ diam.
4.	*Dromæus irroratus*[3] (7 weeks incubation). Do. do. .	do.
5.	*Struthio camelus*[4] (embryo, size of Sparrow). Do. do. .	2 do.
6.	Do. (half-developed embryo). Left Shoulder-girdle moiety; outer view . .	do.
7.	*Rhea americana*[5] (ripe chick). Shoulder-girdle and Sternum; lower view .	$1\frac{1}{2}$ do.
8.	Do. (do.) Section of pleurosteon . .	6 do.
9.	*Dromæus irroratus*[6] (7 weeks incubation). Section of pleurosteon .	do.
10.	*Uria troile*[7] (one-third of incubating period). Shoulder-girdle and Sternum; lower view . .	5 do.
11.	Do. (do.) Sternum; side view . .	do.
12.	Do. (do.) Part of left Shoulder-girdle moiety; outer view . . .	11 do.
13.	Do. (do.) Right half of furcula; hinder view .	15 do.
14.	Do. (almost ripe embryo). Thorax; side view . .	3 do.
15.	*Strigops habroptilus*[8] (adult). Sternum; lower view . . .	$\frac{1}{2}$ nat. size.

[1] See p. 191. [2] See pp. 188, 189. [3] See p. 189. [4] See pp. 187, 188.
See pp. 190, 191. [6] See p. 189. [7] See pp. 146—148. [8] See p. 170.



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Geo West lith

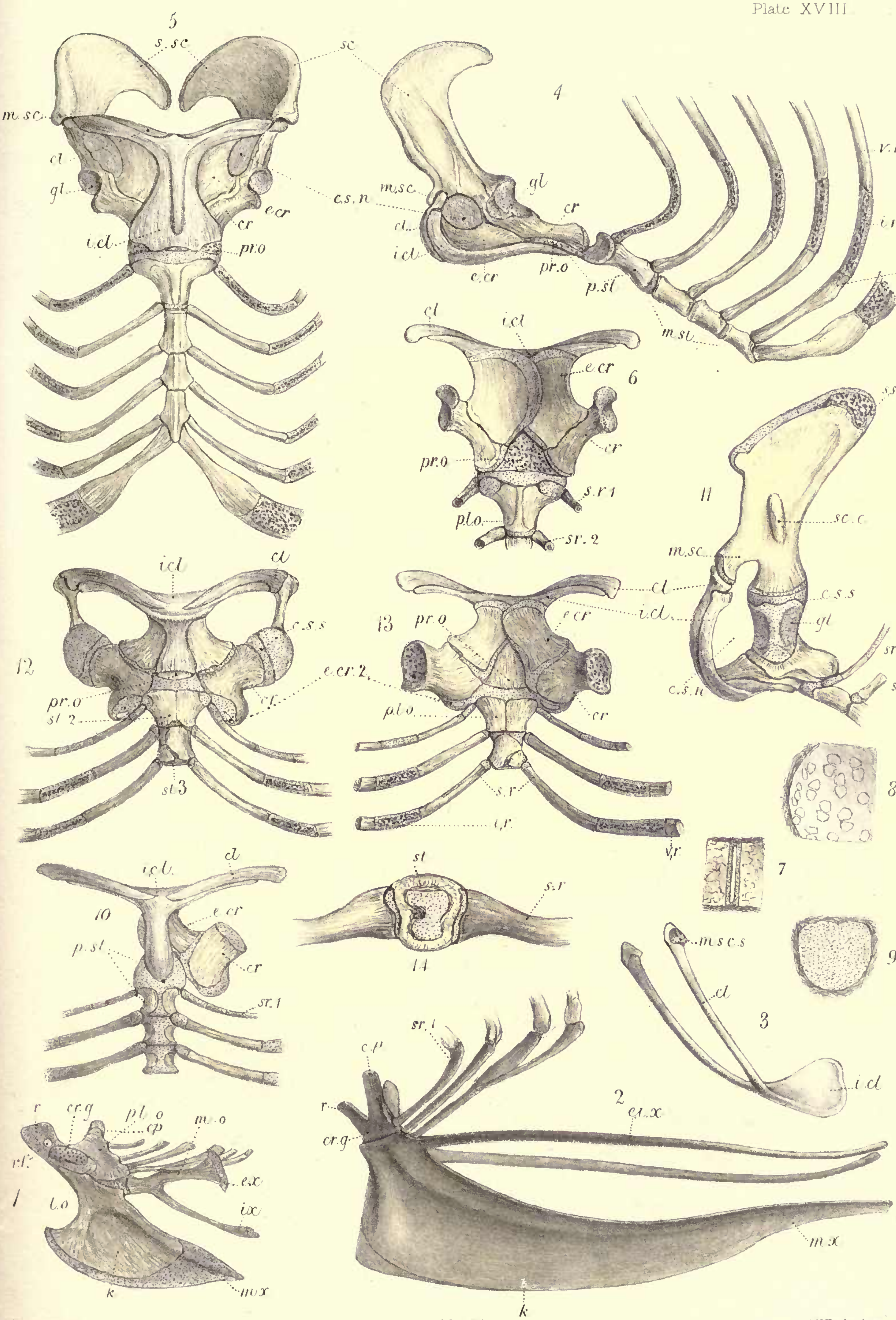
M & N Hanhart imp

1, 2. APTERYX. 3 CASUARIUS 4, 9 DROMÆUS. 5, 6 STRUTHIO. 7, 8 RHEA. 10-14 URIA.
15. STRIGOPS.

PLATE XVIII.

FIG.				SIZE.
1.	*Numida meleagris*[1]	(6 weeks old).	Sternum ; side view . .	nat. size.
2.	*Tinamus robustus*[2]	(adult).	Sternum ; side view . .	do.
3.	*Tetrao cupido*[3]	(do.)	Furcula ; oblique view . .	do.
4.	*Ornithorhynchus paradoxus*[4]	(adult).	Shoulder-girdle and Sternum ; side view	do.
5.	Do.	(do.)	do. lower view	do.
6.	Do.	(do.)	Part of do. ; upper view .	do.
7.	Do.	(do.)	Ideal section of third sternal *synovial* joint . . .	3 diam.
8.	Do.	(do.)	Synovial surface of do. . .	200 do.
9.	Do.	(do.)	do. . .	3 do.
10.	*Echidna histrix*[5]	(half-grown).	Part of Shoulder-girdle and Sternum ; lower view . . .	$1\frac{1}{2}$ do.
11.	Do.	(three-fourths adult).	Shoulder-girdle and part of Sternum ; side view . . .	nat. size.
12.	Do.	(do.)	do. lower view	do.
13.	Do.	(do.)	do. upper do.	do.
14.	Do.	(do.)	Front view of third sternal piece, with part of sternal ribs .	2 diam.

[1] See p. 184. [2] See pp. 185, 186. [3] See p. 184.
[4] See pp. 192, 193. [5] See pp. 193, 194.



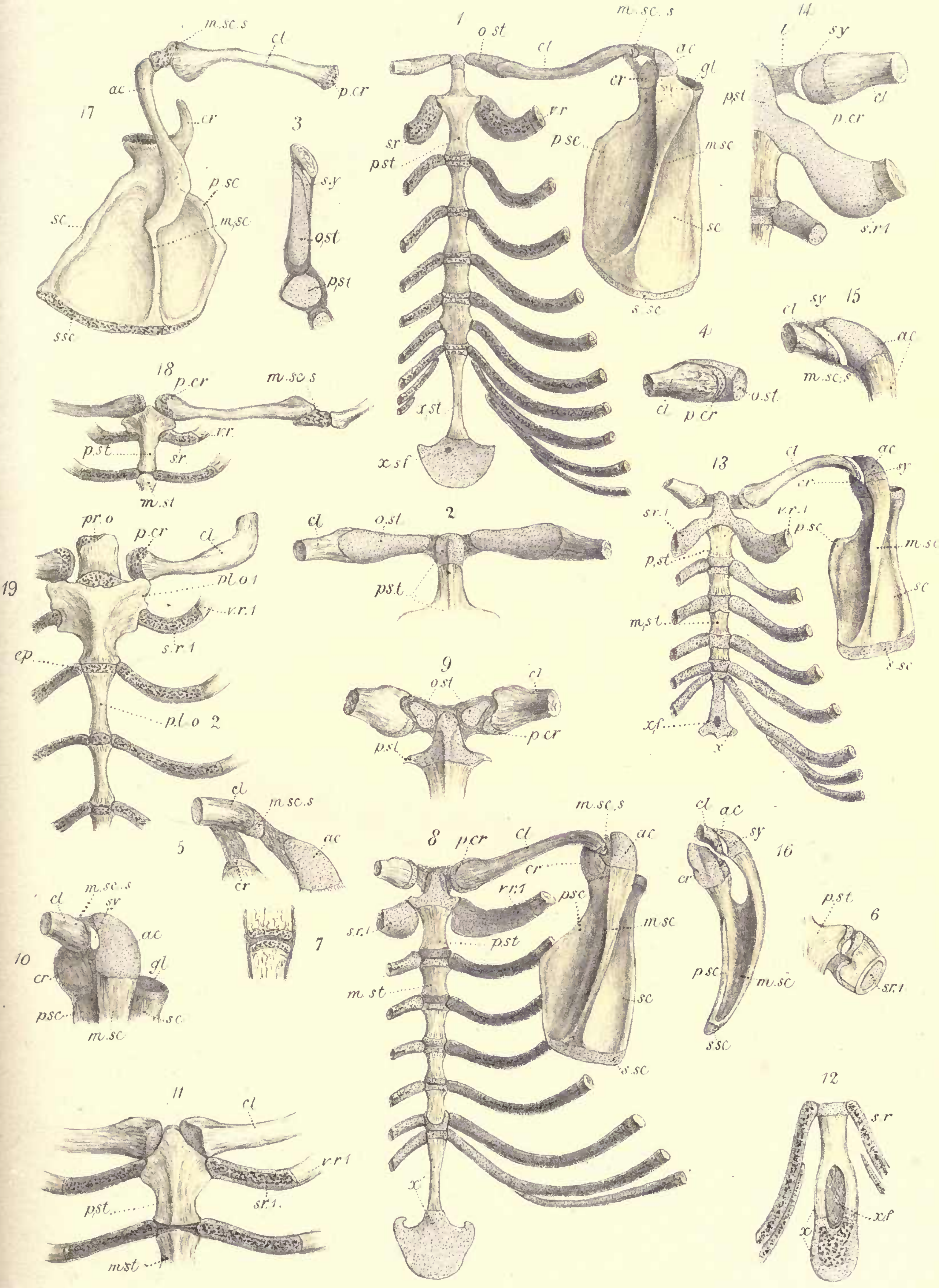
W.K.Parker del. Geo West lith. M & N Hanhart imp

1. NUMIDA. 2 TINAMUS. 3 TETRAO. 4-9 ORNITHORHYNCHUS. 10-14 ECHIDNA.

PLATE XIX.

FIG.				SIZE.
1.	*Didelphys* ——— ?[1]	(adult).	Right scapula, outer, and Sternum, inner view . .	nat. size.
2.	Do.	(do.)	Omosternal cartilages and fore part of præ-sternum; outer view .	2 diam.
3.	Do.	(do.)	do. section	do.
4.	Do.	(do.)	Part of same; inner view .	do.
5.	Do.	(do.)	Junction of clavicle with acromion and coracoid; outer view .	do.
6.	Do.	(do.)	Junction of first sternal rib with præ-sternum . . .	do.
7.	Do.	(do.)	Section of part of meso-sternum .	do.
8.	*Phalangista vulpina*[2]	(one-third adult).	Right scapula, outer, and Sternum, inner view . .	do.
9.	Do.	(do.)	Omosternals, and part of clavicles and præsternum; outer view .	3 do.
10.	Do.	(do.)	Junction of clavicle with scapula .	do.
11.	*Phascolarctos fuscus*[3]	(adult).	Fore part of Sternum and ends of clavicles; outer view . .	nat. size.
12.	Do.	(do.)	Xiphisternum; outer view .	do.
13.	*Phascolomys Wombat*[4]	(one-third adult).	Right scapula, outer, and Sternum inner view . .	do.
14.	Do.	(do.)	Part of same . .	2 diam.
15.	Do.	(do.)	Junction of clavicle with acromion; outer view . .	do.
16.	Do.	(do.)	Scapula; front view . .	nat. size.
17.	*Bathyergus maritimus*[5]	(adult male).	Left scapula and clavicle; outer view	do.
18.	Do.	(adult female).	Clavicles and præ-sternum; outer view . . .	do.
19.	*Helamys capensis*[6]	(adult).	Clavicles and fore part of Sternum; outer view . .	do.

[1] See pp. 196—198. [2] See pp. 196—198. [3] See pp. 196—198.
[4] See pp. 196—198. [5] See pp. 207—210. [6] See pp. 207—210.

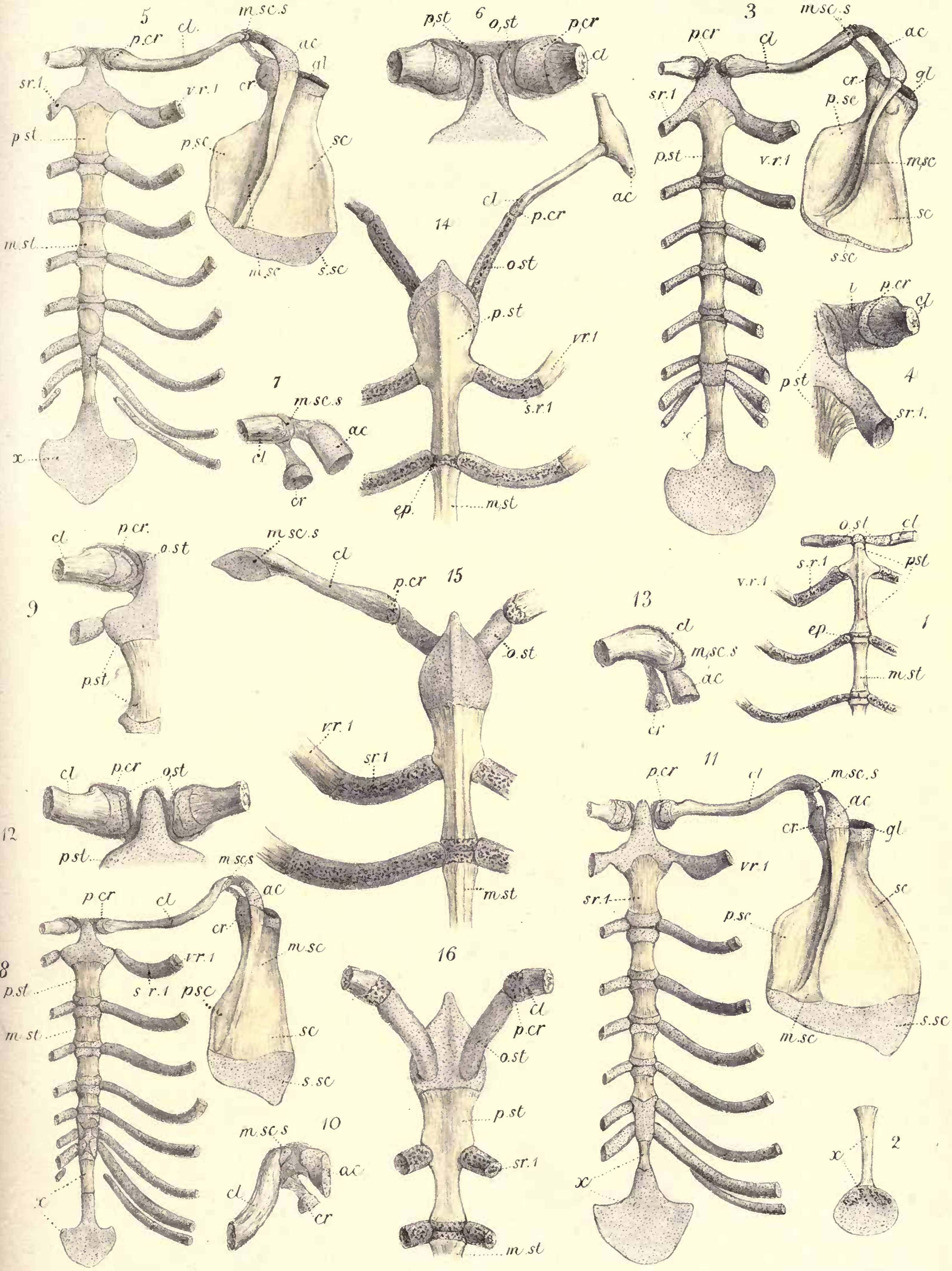


1-7 DIDELPHYS . 8-10 PHALANGISTA. 11,12 PHASCOLARCTOS. 13-16 PHASCOLOMYS.
17,18 BATHYERGUS. 19 HELAMYS.

PLATE XX.

FIG.			SIZE.
1.	*Dasyurus ursinus*[1] (adult).	Omosternals and fore part of Sternum; outer view	nat. size.
2.	Do. (do.)	Xiphisternum . . .	do.
3.	*Halmaturus Bennettii*[2] (10 inches 4 lines long—nose to end of sacrum).	Right scapula, outer, and Sternum, inner view .	$1\frac{1}{2}$ diam.
4.	Do. (do.)	Part of same . . .	3 do.
5.	Do. (3 inches 2 lines long).	Right scapula, outer, and Sternum, inner view . .	5 do.
6.	Do. (do.)	Junction of clavicle with scapula; outer view . .	10 do.
7.	Do. (do.)	Junction of clavicles with præsternum; inner view . .	do.
8.	*Bettongia Grayi*[3] (2 inches 6 lines long).	Right scapula, outer, and Sternum, inner view . .	5 do.
9.	Do. (do.)	Junction of clavicle with præsternum; inner view . .	10 do.
10.	Do. (do.)	Junction of clavicle with scapula; outer view . .	do.
11.	*Petrogale xanthopus*[4] (3 inches 1 line long).	Right scapula, outer, and Sternum, inner view . .	5 do.
12.	Do. (do.)	Junction of clavicles with præsternum; inner view .	10 do.
13.	Do. (do.)	Junction of clavicle with scapula; outer view . .	do.
14.	*Hystrix alophus*[5] (young).	Omosternals, clavicles, and præsternum; outer view . .	nat. size.
15.	,, *cristata*[6] (adult).	Do. do. .	do.
16.	Do. (do.)	Do. do.; inner view	do.

[1] See pp. 196—198.
[2] See pp. 196—198.
[3] See pp. 196—198.
[4] See pp. 196—198.
See pp. 209, 210.
[6] See pp. 208—210.



Geo West lith. W K Parker del.t M & N Hanhart imp.

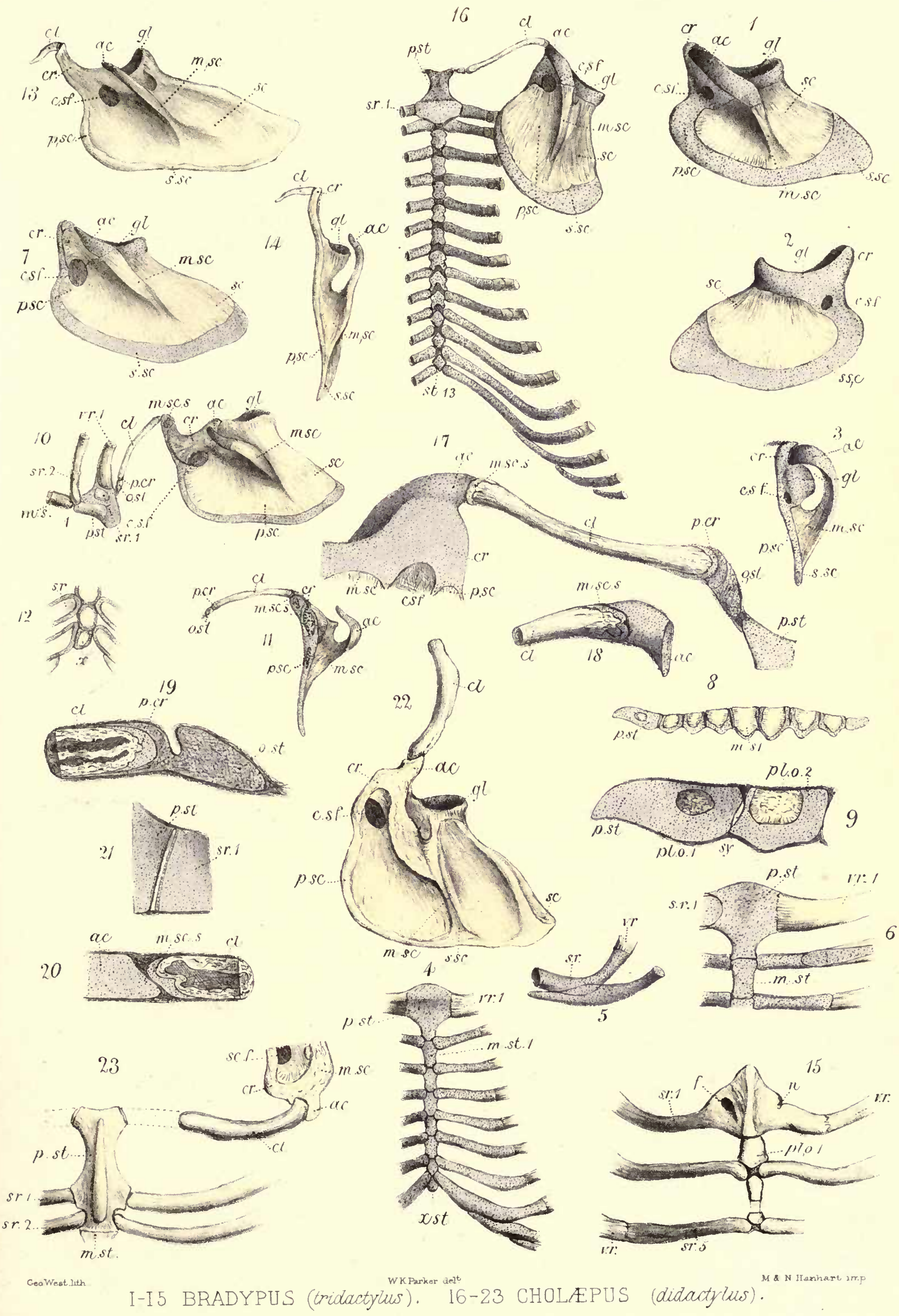
1,2 DASYURUS. 3-7 HALMATURUS. 8-10 BETTONGIA. 11-13 PETROGALE.
14 HYSTRIX (*alophus*). 15,16 H. (*cristata*).

PLATE XXI.

FIG.				SIZE.
1.	*Bradypus tridactylus*[1]	(embryo).	Right scapula; outer view	$2\frac{2}{3}$ diam.
2.	Do.	(do.)	do. inner view	do.
3.	Do.	(do.)	do. front view	do.
4.	Do.	(do.)	Sternum; outer view	do.
5.	Do.	(do.)	Last fixed and first floating ribs; inner view	4 do.
6.	Do.	(do.)	Fore-part of Sternum; inner view	do.
7.	Do.	(one-third grown).	Right scapula; outer view	$1\frac{1}{3}$ do.
8.	Do.	(do.)	Section of Sternum	nat. size.
9.	Do.	(do.)	Fore-part of same	3 diam.
10.	Do.	(half-grown).	Right scapula, and fore-part of Sternum; outer view	$\frac{3}{4}$ nat. size.
11.	Do.	(do.)	do. front view	do.
12.	Do.	(nearly adult).	Hind part of Sternum; outer view	do.
13.	Do.	(old).	Right scapula; outer view	$\frac{2}{3}$ do.
14.	Do.	(do.)	do. front view	do.
15.	Do.	(do.)	Sternum, fore-part and middle; outer view	nat. size.
16.	*Cholæpus didactylus*[2]	(8 in. long).	Right scapula, outer view, and sternum in horizontal section from above	$1\frac{1}{3}$ diam.
17.	Do.	(do.)	Junction of clavicle with acromion and præ-sternum; lower view	4 do.
18.	Do.	(do.)	do. with acromion; outer view	do.
19.	Do.	(do.)	Omosternum and end of clavicle in section	8 do.
20.	Do.	(do.)	Junction of clavicle with acromion—section	do.
21.	Do.	(do.)	do. 1st rib with Sternum	6 do.
22.	Do.	(old).	Right scapula and clavicle; outer view	$\frac{2}{3}$ nat. size.
23.	Do.	(do.)	Præ-sternum; clavicle, and part of scapula; outer view	do.

[1] See pp. 199, 200.

[2] See pp. 199, 200.



Geo West lith. W K Parker delt M & N Hanhart imp.

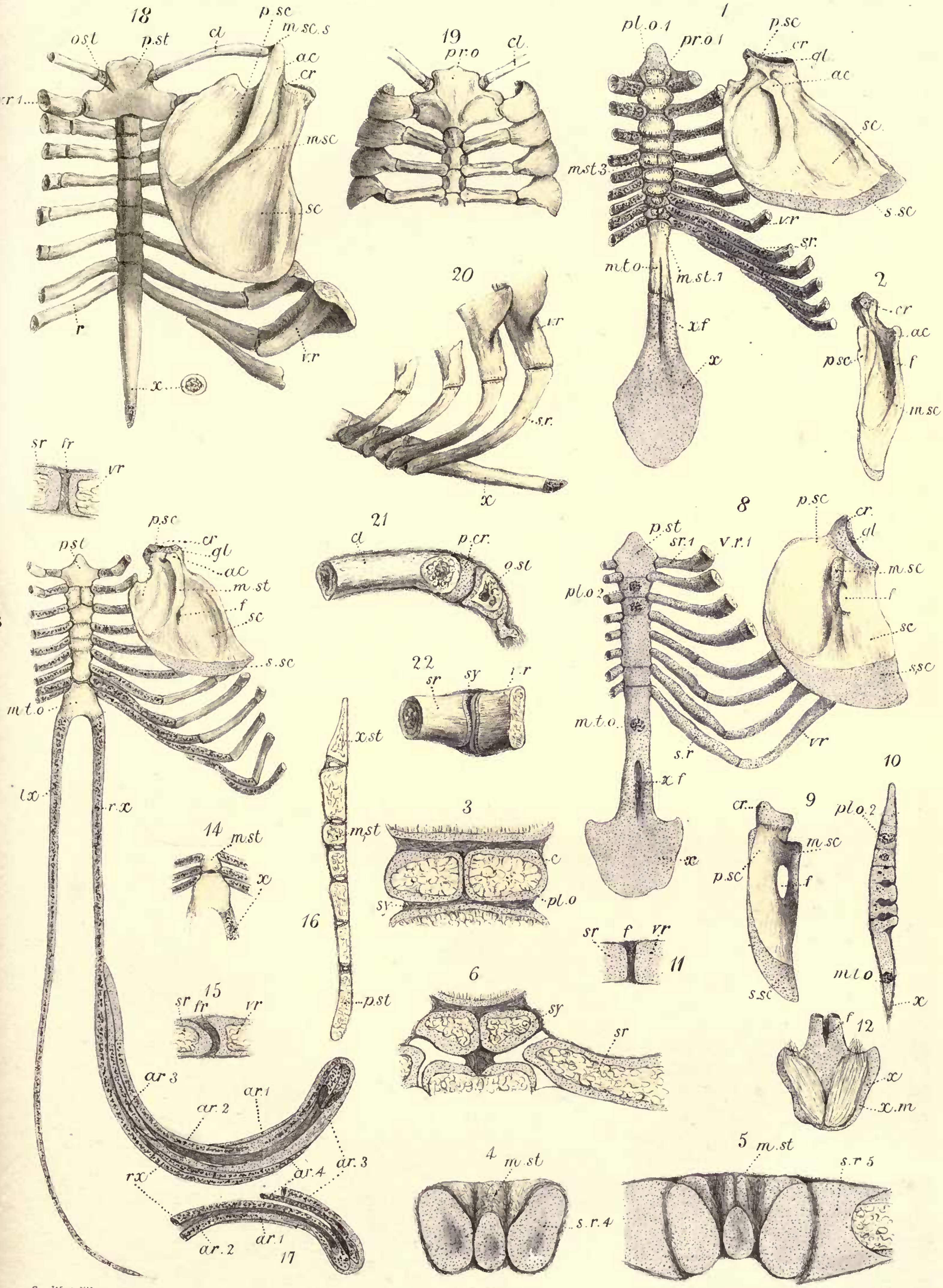
I-15 BRADYPUS (*tridactylus*). 16-23 CHOLÆPUS (*didactylus*).

PLATE XXII.

FIG.				SIZE.
1.	*Pholidotus Dalmannii*[1]	(adult).	Right scapula, outer, and Sternum, inner view	$\frac{2}{3}$ nat. size.
2.	Do.	(do.)	Scapula; front view . . .	do.
3.	Do.	(do.)	3rd mesosternal; horizontal section .	3 diam.
4.	Do.	(do.)	Posterior end of 2nd mesosternal .	do.
5.	Do.	(do.)	Front end of 3rd mesosternal, and ends of 4th sternal ribs . . .	do.
6.	Do.	(do.)	Horizontal section of last mesosternal, and fore-part of xiphoid . .	do.
7.	Do.	(do.)	Junction of sternal with vertebral rib .	do.
8.	Do.	(very young).	Right scapula, outer, and Sternum, inner view	$1\frac{1}{3}$ do.
9.	Do.	(do.)	Scapula; front view . .	do.
10.	Do.	(do.)	Sternum; section . . .	do.
11.	Do.	(do.)	Junction of sternal with vertebral rib .	4 do.
12.	Do.	(do.)	Xiphisternum and muscles; outer view .	$1\frac{1}{3}$ do.
13.	*Manis longicauda*[2]	(adult).	Right scapula, outer, and Sternum, inner view	$\frac{2}{3}$ nat. size.
14.	Do.	(do.)	Part of same; outer view . .	do.
15.	Do.	(do.)	Junction of vertebral and sternal rib .	3 diam.
16.	Do.	(do.)	Section of Sternum (inverted view) .	$1\frac{1}{3}$ do.
17.	Do.	(do.)	End of right xiphisternum and abdominal ribs; outer view . . .	$\frac{2}{3}$ nat. size.
18.	*Cyclothurus didactylus*[3]	(adult).	Right scapula, outer, and Sternum, inner view . . .	$1\frac{1}{2}$ diam.
19.	Do.	(do.)	Fore-part of thorax; lower view .	do.
20.	Do.	(do.)	Posterior half of sternum and the corresponding ribs; outer view . .	do.
21.	Do.	(do.)	Distal part of clavicle and omosternal .	6 do.
22.	Do.	(do.)	Joint of last true rib . .	3 do.

[1] See pp. 200—202. [2] See pp. 200—202. [3] See pp. 202—204.

Plate XXII



Geo West lith.

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M & N Hanhart imp

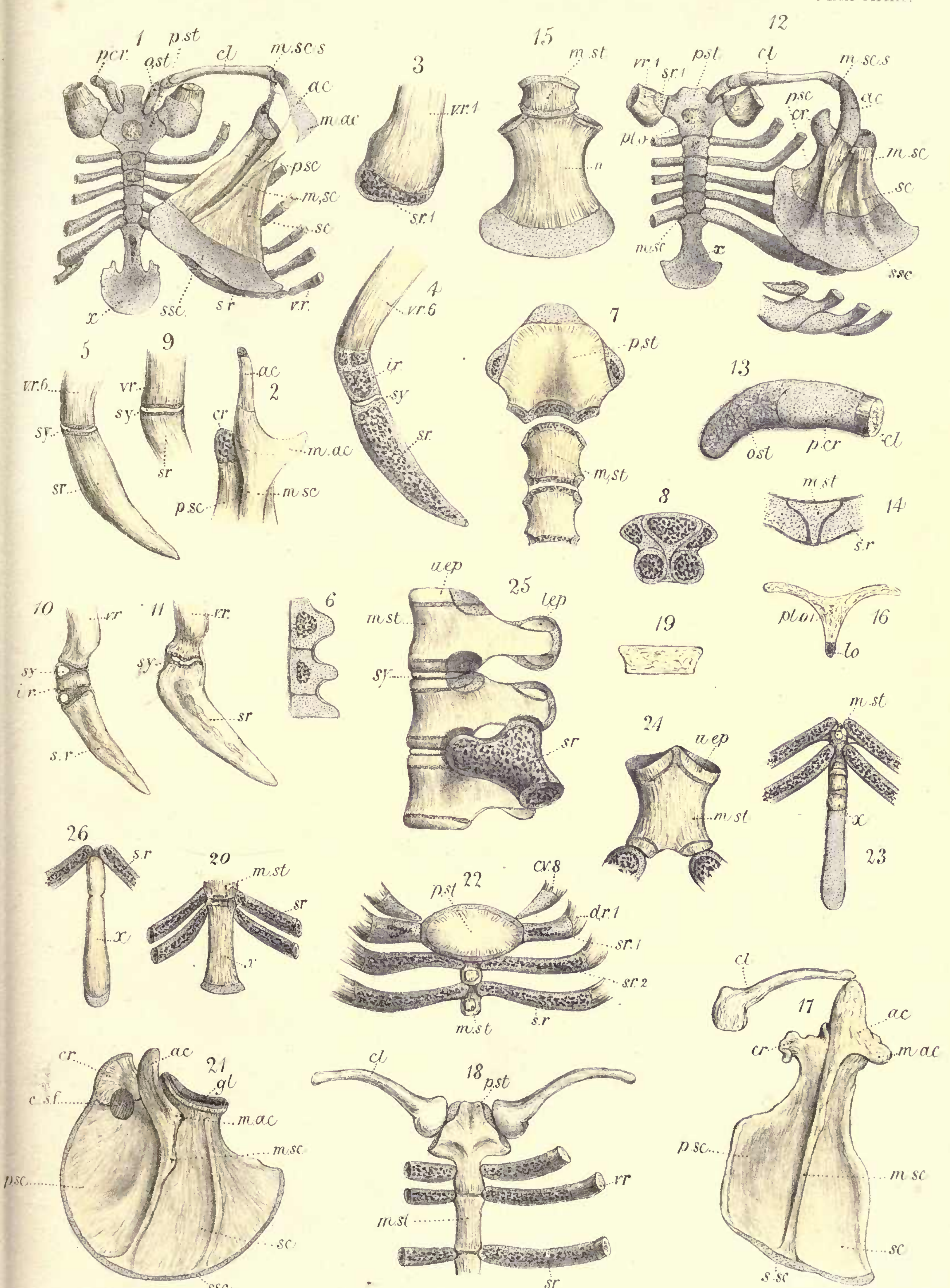
I-12. PHOLIDOTUS (*Dalmanii*). 13-17 MANIS (*longicauda*). 18-22 CYCLOTHURUS (*didactylus*).

PLATE XXIII.

FIG.			SIZE.
1.	*Tatusia peba*[1] (ripe embryo).	Right scapula, outer, and Sternum, inner view	$2\frac{1}{2}$ diam.
2.	Do. (two-thirds adult).	Base of scapula; outer view	nat. size.
3.	Do. (do.)	1st left rib	do.
4.	Do. (do.)	6th right rib	do.
5.	Do. (very old).	do.	do.
6.	Do. (ripe embryo).	Section of fore-part of Sternum	5 diam.
7.	Do. (three-fourths adult).	Fore-part of Sternum; upper view	$1\frac{1}{2}$ do.
8.	Do. (do.)	Posterior surface of 1st mesosternal joint	2 do.
9.	*Xenurus unicinctus*[2] (old).	Joint of middle rib	nat. size.
10.	*Dasypus sexcinctus*[3] (adult).	Last rib but two	do.
11.	Do. (do.)	do. three	do.
12.	*Euphractus villosus*[4] (ripe embryo).	Right scapula, outer, and Sternum, inner view	2 diam.
13.	Do. (do.)	Præ-coracoid and omosternal	6 do.
14.	Do. (do.)	Free surface of 1st mesosternal, and section of sternal ribs	3 do.
15.	*Prionodos gigas*[5] (adult).	Last mesosternal and xiphisternum	$\frac{2}{3}$ nat. size.
16.	Do. (do.)	Ideal section of præ-sternum	do.
17.	*Orycteropus capensis*[6] (old).	Right scapula and clavicle; outer view	$\frac{1}{3}$ do.
18.	Do. (do.)	Clavicles and fore-part of Sternum; outer view	do.
19.	Do. (do.)	Ideal section of mesosternal	nat. size.
20.	Do. (do.)	Xiphisternum; outer view	$\frac{1}{3}$ do.
21.	*Myrmecophaga jubata*[7] (adult).	Right scapula; outer view	do.
22.	*Tamandua bivittata*[8] (three-fourths adult.)	Fore-part of thorax; outer view	nat. size.
23.	Do. (do.)	Hinder part of Sternum; outer view	do.
24.	Do. (do.)	A mesosternal segment,[9] with lower heads of sternal ribs; outer view	4 diam.
25.	Do. (do.)	Three mesosternals, with heads of sternal ribs; side view	do.
26.	Do. (old).	Xiphisternum	nat. size.

[1] See pp. 205—207. [2] See pp. 205—207. [3] See pp. 205—207. [4] See pp. 205—207.
[5] See pp. 205—207. [6] See pp. 202, 203. [7] See p.204. [8] See pp. 204, 205.

[9] In figs. 24 and 25, from above and laterally, the parts are drawn in a diagrammatic manner, and the head of the sternal rib in fig. 25 is pushed *downwards;* in fig. 24 the upper heads of a pair of ribs are shown attached behind a mesosternal segment; but they *converge* too much in the figure, and lie in reality on a much lower plane than the upper surface of the sternal segment (see fig. 25).



Geo West lith. W.K.Parker del[t] M & N Hanhart imp

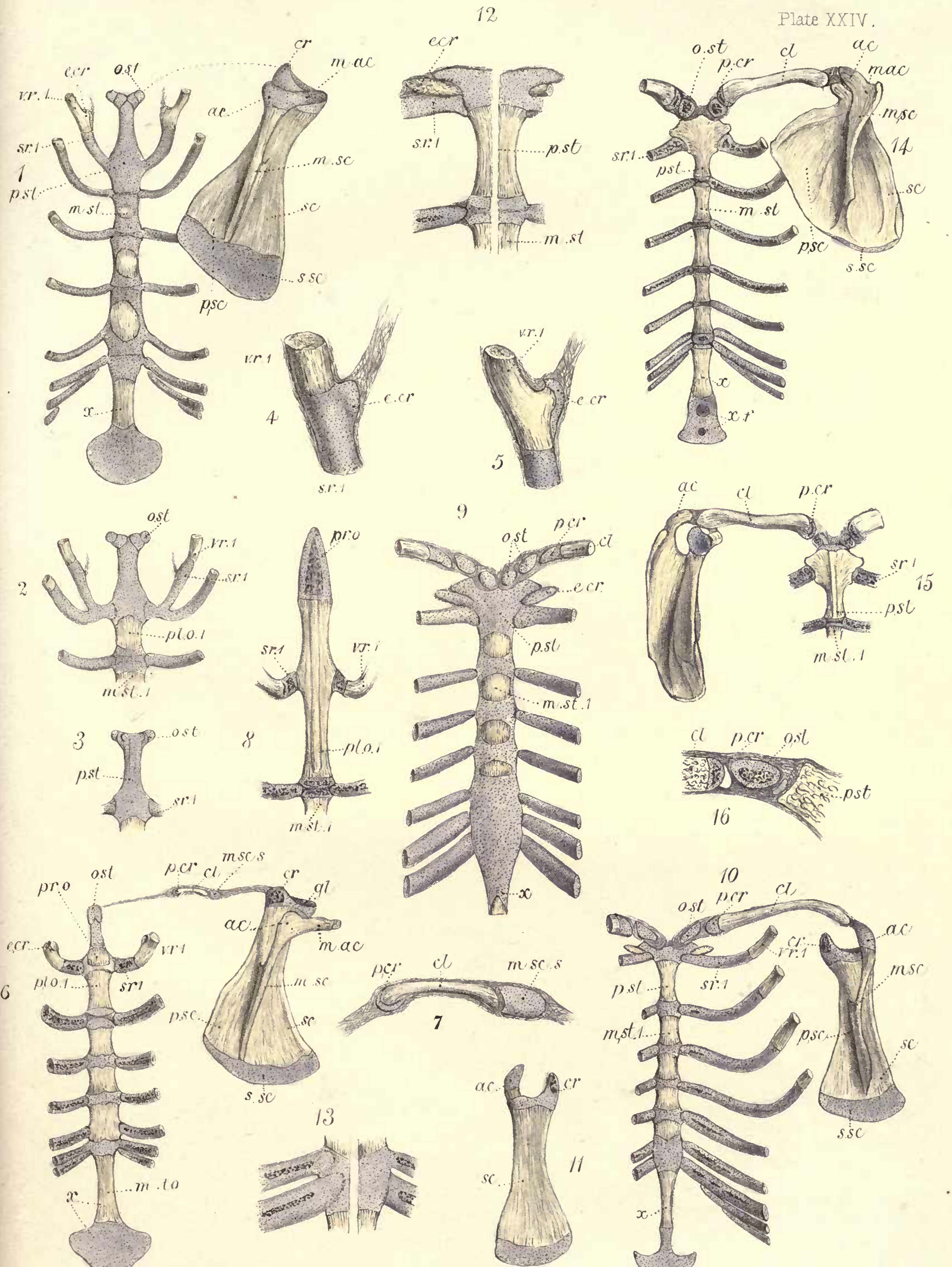
1-8 TATUSIA. 9 XENURUS. 10,11 DASYPUS. 12-14 EUPHRACTUS. 15,16 PRIONODOS.
17-20. ORYCTEROPUS. 21. MYRMECOPHAGA. 22-26 TAMANDUA.

PLATE XXIV.

FIG.			SIZE.
1.	*Cavia aperea*[1] (nearly ripe embryo).	Right scapula, outer, and Sternum, inner view	$4\frac{2}{3}$ diam.
2.	Do. (another, at same stage).	Fore-part of Sternum; inner view	do.
3.	Do. (do.)	Part of same; outer view	do.
4.	Do. (1st embryo).	Right epicoracoid and 1st rib; outer view	$9\frac{1}{3}$ do.
5.	Do. (do.)	Left epicoracoid and 1st rib; inner view	do.
6.	Do. (a month old).	Right scapula, outer, and Sternum, inner view	$1\frac{1}{3}$ do.
7.	Do. (do.)	Clavicle and cartilages	$2\frac{2}{3}$ do.
8.	*Dasyprocta acouchi*[2] (adult).	Præ-sternum; lower view	2 do.
9.	*Arvicola agrestis*[3] (almost ripe embryo).	Sternum and part of Shoulder-girdle	15 do.
10.	Do. (3 or 4 days old).	Right scapula, outer, and Sternum, inner view	$6\frac{2}{3}$ do.
11.	Do. (do.)	Right scapula; inner view	do.
12.	Do. (do.)	Præ-sternum and epicoracoid; upper and lower views	$12\frac{1}{3}$ do.
13.	Do. (do.)	Commencement of xiphisternum; upper and lower view	$13\frac{1}{3}$ do.
14.	*Arctomys ludovicianus*[4] (adult).	Right scapula, outer, and Sternum, inner view	nat. size.
15.	Do. (do.)	Scapula, posterior view, and fore-part of Sternum, lower view	do.
16.	Do. (do.)	Section, showing relation of omosternum to clavicle and præ-sternum	3 diam.

[1] See pp. 207—210. [2] See pp. 207—210. [3] See pp. 207—210. [4] See pp. 207—210.

Plate XXIV.



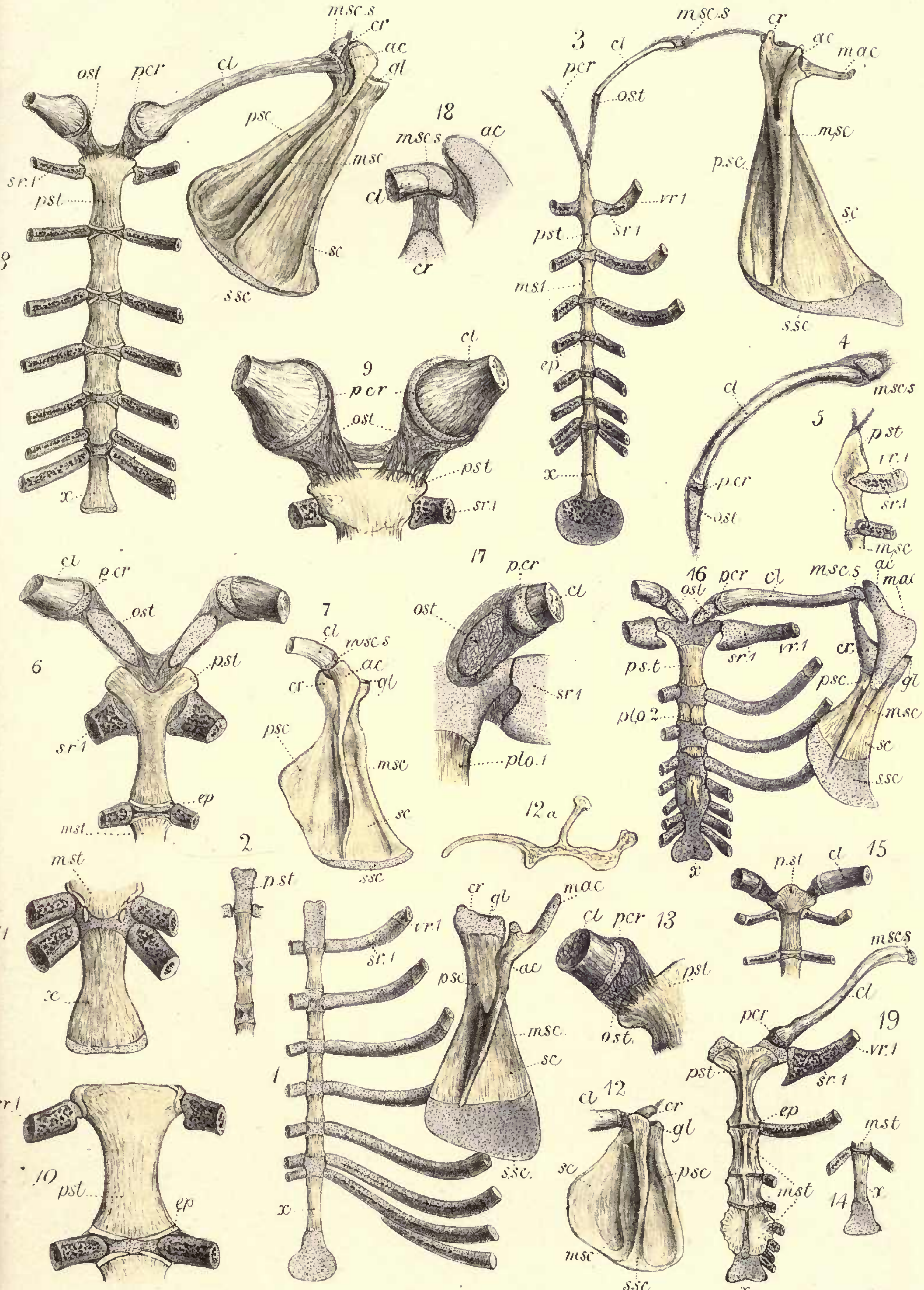
Geo West lith W K Parker del[t] M & N Hanhart imp

1-7 CAVIA. 8 DASYPROCTA. 9-13 ARVICOLA. 14-16 ARCTOMYS.

PLATE XXV.

FIG.			SIZE.
1.	*Lepus cuniculus*[1] (nearly ripe embryo).	Right scapula, outer, Sternum, inner view . .	$3\frac{2}{3}$ diam.
2.	Do. (do.)	Fore-part of Sternum; outer view	do.
3.	Do. (three fourths adult).	Right scapula, outer, and Sternum, inner view . .	nat. size.
4.	Do. (do.)	Clavicle and cartilages .	2 diam.
5.	Do. (do.)	Præ-sternum; side view .	nat. size.
6.	*Cricetus vulgaris*[2] (adult).	Omosternals and præ-sternum; inner view .	3 diam.
7.	Do. (do.)	Right scapula; outer view . .	$1\frac{1}{2}$ do.
8.	*Myoxus avellanarius*[3] (adult).	Right scapula, outer, and Sternum, inner view	6 do.
9.	Do. (do.)	Junction of clavicles with præ-sternum; inner view . . .	12 do.
10.	Do. (do.)	Præ-sternum; inner view . .	do.
11.	Do. (do.)	Xiphisternum; inner view . .	do.
12.	*Sciurus palmarum*[4] (adult).	Left scapula; outer view . .	2 do.
12*a*.	Do. (do.)	Section of scapula . . .	3 do.
13.	Do. (do.)	Junction of clavicle with præ-sternum; inner view	4 do.
14.	Do. (do.)	Xiphisternum . . .	2 do.
15.	Do. (do.)	Præ-sternum and end of clavicles . .	do.
16.	*Erinaceus europæus*[5] (1st week, 3 inches long).	Right scapula, outer, and Sternum, inner view .	3 do.
17.	Do. (do.)	Omosternal and præ-sternum, inner view . .	8 do.
18.	Do. (do.)	Junction of clavicle with scapula; outer view .	do.
19.	Do. (adult).	Clavicle and Sternum; outer view . .	$1\frac{1}{2}$ do.

[1] See pp. 207—210. [2] See pp. 207—210. [3] See pp. 207—210.
[4] See pp. 207—210. [5] See pp. 210—213.



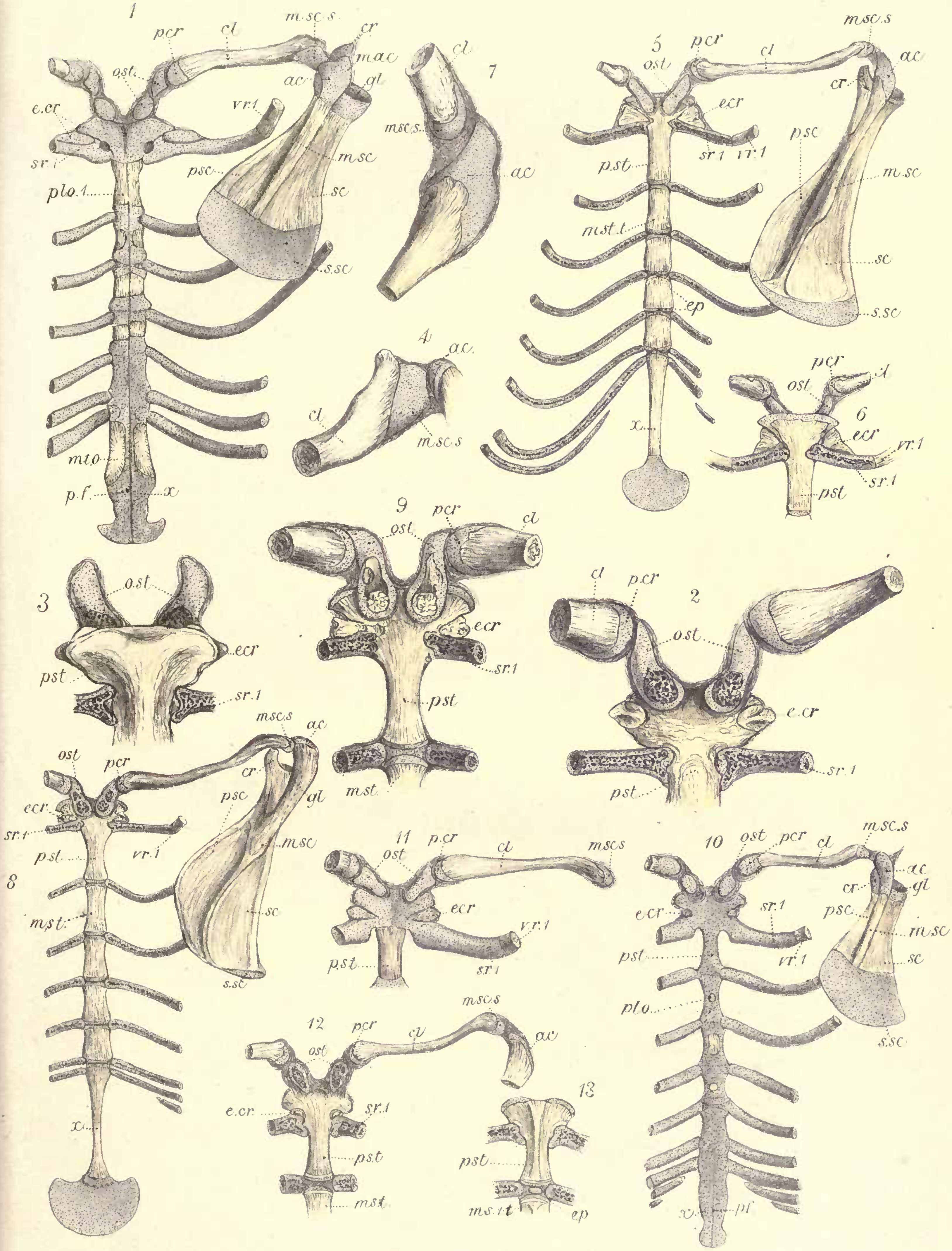
Geo West lith. W K Parker del. M & N Hanhart imp.

1-5 LEPUS. 6-7 CRICETUS. 8-11 MYOXUS. 12-15 SCIURUS. 16-19 ERINACEUS.

PLATE XXVI.

FIG.				SIZE.
1.	*Mus musculus*[1]	(nearly ripe).	Right scapula, outer, and Sternum, inner view	15 diam.
2.	Do.	(adult).	Junction of Shoulder-girdle with præ-sternum; inner view . .	12 do.
3.	Do.	(do.)	The same (part); outer view . .	do.
4.	Do.	(do.)	Junction of clavicle with acromion; outer view	do.
5.	*Mus sylvaticus*[2]	(half-grown).	Right scapula, outer, and Sternum, inner view	6 do.
6.	Do.	(do.)	Part of same; outer view . .	do.
7.	Do.	(do.)	Junction of clavicle with acromion; outer view	12 do.
8.	*Mus minutus*[3]	(3 or 4 years old).	Right scapula, outer, and Sternum, inner view	6 do.
9.	Do.	(do.)	Part of same; inner view . .	12 do.
10.	*Mus decumanus*[4]	(2 or 3 days before birth).	Right scapula, outer, and Sternum, inner view .	8 do.
11.	Do.	(4 or 5 days old).	Clavicles and præ-sternum; inner view . .	$6\frac{2}{3}$ do.
12.	Do.	(three-fourths adult).	Clavicles and fore part of Sternum; inner view .	2 do.
13.	Do.	(do.)	Part of same; outer view .	do.

[1] See pp. 207—210.
[2] See pp. 207—210.
[3] See pp. 207—210.
[4] See pp. 207—210.



Geo West lith. W.K. Parker del[t] M & N Hanhart imp.

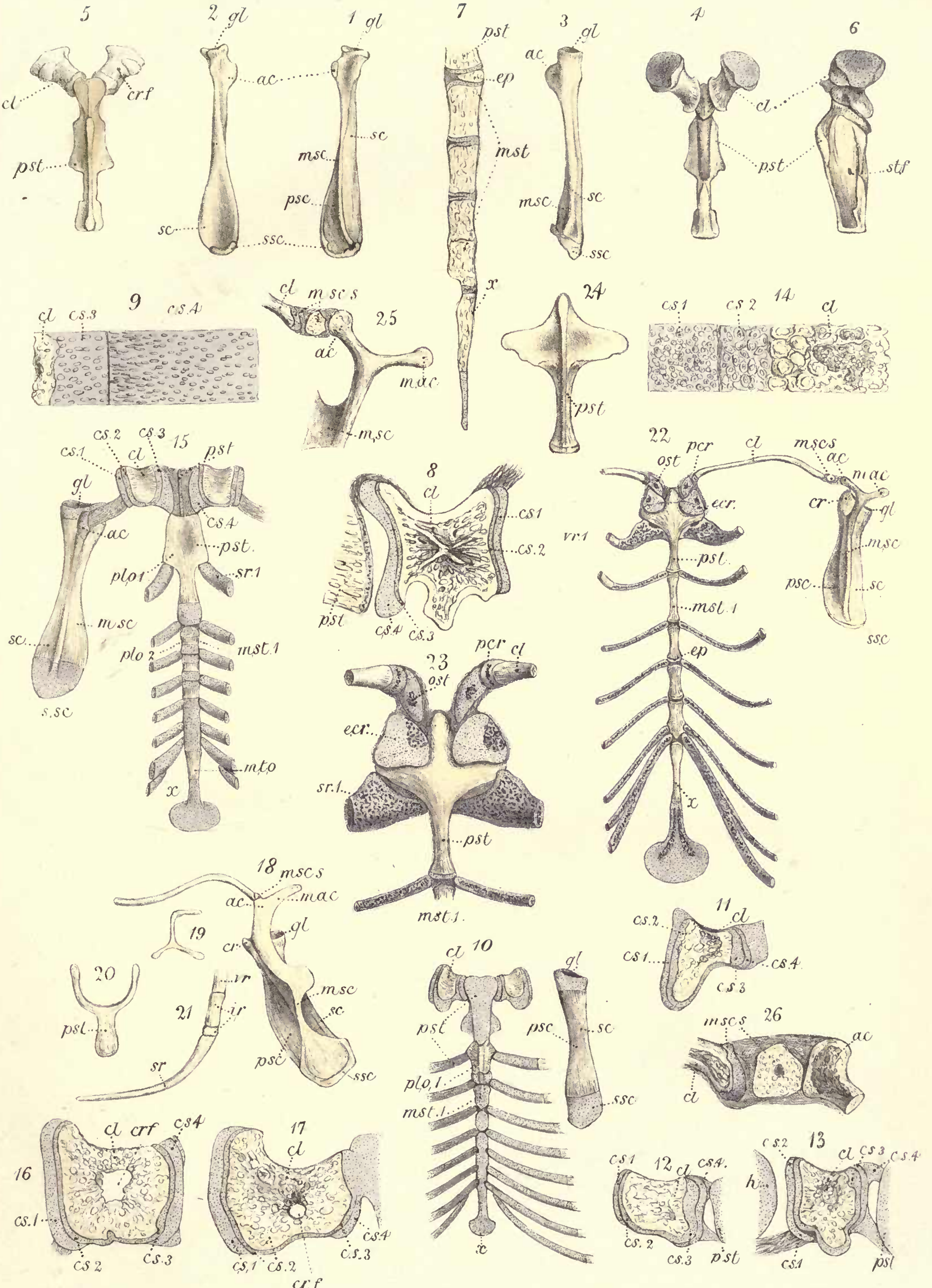
1-4 MUS (*musculus*). 5-7 MUS (*sylvaticus*). 8, 9 MUS (*minutus*).
10-13 MUS (*decumanus*).

PLATE XXVII.

FIG.				SIZE.
1.	*Talpa europæa*[1]	(adult).	Right scapula; outer view . . .	2 diam.
2.	Do.	(do.)	do. inner view . . .	do.
3.	Do.	(do)	do. front view . . .	do.
4.	Do.	(do.)	Clavicles and præ-sternum; inner view .	do.
5.	Do.	(do.)	do. outer view .	do.
6.	Do.	(do.)	do. side view .	do.
7.	Do.	(do.)	Section of Sternum, with part of præ-sternum absent	3 do.
8.	Do.	(do.)	Section of clavicle . . .	5 do.
9.	Do.	(do.)	Part of same section . . .	100 do.
10.	Do.	(3 or 4 days old).	Left scapula, inner, and Sternum, outer view .	$3\frac{3}{4}$ do.
11.	Do.	(do.)	An anterior section obliquely from right to left of clavicle and cartilages . . .	$7\frac{1}{2}$ do.
12.	Do.	(do.)	do. through the middle .	do.
13.	Do.	(do.)	do. through the inferior boss	do.
14.	Do.	(do.)	Part of same	150 do.
15.	Do.	(8 or 10 days old)	Left scapula, outer, and Sternum, inner view .	$3\frac{1}{3}$ do.
16.	Do.	(do.)	Section of clavicle and cartilages, transversely vertical	$6\frac{2}{3}$ do.
17.	Do.	(do.)	do. further forwards .	do.
18.	*Chrysochloris capensis*[2]	(adult).	Right scapula and clavicle; outer view .	2 do.
19.	Do.	(do.)	Section of do. (ideal) . .	do.
20.	Do.	(do.)	Do. of manubrium (do.) . .	4 do.
21.	Do.	(do.)	Left 12th rib . . .	do.
22.	*Crocidura* —— ?[3]	(adult).	Right scapula, outer, Sternum, inner view .	7 do.
23.	Do.	(do.)	Part of same . . .	14 do.
24.	Do.	(do.)	Præ-sternum; outer view . .	do.
25.	Do.	(do.)	Junction of clavicle with acromion; outer view	do.
26.	Do.	(do.)	Part of same . . .	28 do.

[1] See pp. 210—213. [2] See pp. 210—213. [3] See pp. 210—213.

Plate XXVII



Geo West lith. W K Parker delt M & N Hanhart imp

1 - 17 - TALPA . 18 - 21 - CHRYSOCHLORIS. 22 - 26 CROCIDURA -

PLATE XXVIII.

FIG.				SIZE.
1.	*Sorex tetragonurus*[1]	(adult).	Left scapula, inner, and Sternum, outer view .	5 diam.
2.	Do.	(do.)	Left scapula and clavicle; outer view .	do.
3.	Do.	(do.)	do. front view .	do.
4.	Do.	(do.)	Junction of clavicle with acromion . .	20 do.
5.	Do.	(do.)	Part of fig. 1	10 do.
6.	Do.	(do.)	Junction of clavicles with præ-sternum; view from above . . .	do.
7.	Do.	(do.)	do. inner view	do.
8.	*Amphisorex fodiens*[2]	(adult).	Præ-sternum and ends of clavicles; outer view	do.
9.	*Pteropus edulis*[3]	(adult).	Clavicles and fore part of sternum; outer view .	nat. size.
10.	Do.	(do.)	Part of same	2 diam.
11.	*Scotophilus pipistrellus*[4]	(8 or 10 weeks old).	Left scapula, inner, and Sternum, outer view . .	5 do.
12.	Do.	(do.)	Left scapula and clavicle; outer view . . .	do.
13.	Do.	(do.)	do. front view	do.
14.	Do.	(do.)	Præ-sternum; upper view .	10 do.
15.	Do.	(do.)	do. inner view .	do.
16.	Do.	(do.)	Sternal end of clavicle :	do.
17.	*Plecotus auritus*[5]	(adult).	Junction of clavicles with præ-sternum; outer view	4 do
18.	*Molossus* —— ?[6]		Left scapula; outer view . . .	2½ do.
19.	*Mycetes seniculus*[7]	(adult).	Junction of clavicles with præ-sternum; outer view	nat. size.
20.	*Mycetes ursinus* ?[8]	(adult.)	Do. do. do. .	do.

[1] See pp. 210—213. [2] See pp. 210—213. [3] See pp. 214, 215. [4] See p. 214, 215.
[5] See pp. 214, 215. [6] See pp. 214, 215. [7] See p. 223. [8] See p. 223.

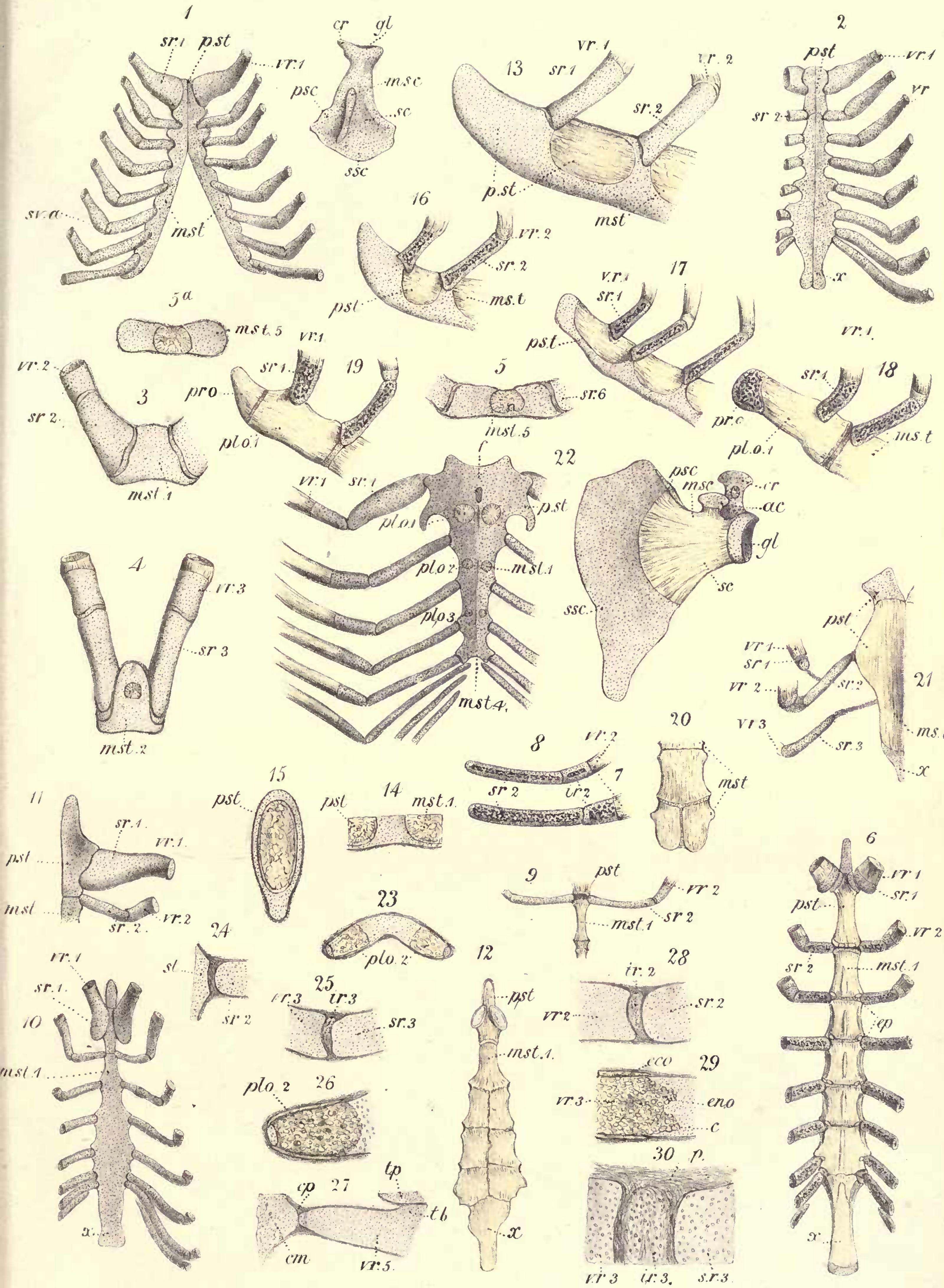
Geo West lith. W K Parker delt. M & N Hanhart imp.

1-7 SOREX. 8 AMPHISOREX. 9, 10 PTEROPUS. 11-16 SCOTOPHILUS.
17 PLECOTUS. 18 MOLOSSUS. 19. MYCETES (*Seniculus*). 20 MYCETES (*Ursinus*)

PLATE XXIX.

FIG.			SIZE.
1.	*Bos taurus*[1] (embryo 1 inch 4 lines long).	Right scapula, outer, and Sternum, inner view . .	6 diam.
2.	Do. (do., 2 inches 8 lines long).	Sternum; inner view . .	4 do.
3.	Do. (do., 6 inches 6 lines long).	Front face of mesosternum, and section of 2nd sternal ribs .	do.
4.	Do. (do., 6 inches 6 lines long).	Section of 2nd mesosternal region, near 3rd sternal ribs .	do.
5.	Do. (do.)	Section of 5th mesosternal region, and 6th sternal ribs . .	do.
5*a*.	Do. (do.)	Another section through the same osseous centre . .	do.
6.	*Tragulus javanicus*[2] (adult).	Sternum; upper view . . .	nat. size.
7.	*Hyrax capensis*[3] (do.)	2nd rib, lower part . .	reduced.
8.	Do. (half-grown).	Do. do. . .	do.
9.	Do. (a week or two old).	Part of Sternum, and 2nd ribs .	nat. size.
10.	*Sus scrofa*[4] (embryo 4 inches long).	Sternum; inner view . .	$2\frac{2}{3}$ diam.
11.	Do. (do.)	Fore part of Sternum; side view .	4 do.
12.	Do. (adult).	Sternum; inner view . .	$\frac{1}{4}$ nat. size.
13.	*Equus asinus*[5] (2 weeks old).	Fore part of Sternum; side view .	nat. size.
14.	Do. (do.)	Horizontal section through the same .	2 diam.
15.	Do. (do.)	Vertical section of presternum .	2 do.
16.	*Equus caballus*[6] (adult).	Fore part of Sternum; side view . .	$\frac{1}{8}$ nat. size.
17.	*Hippopotamus amphibius*[7] (half-grown).	Fore part of Sternum; side view .	do.
18.	Do. (adult).	Do. . . .	do.
19.	*Tapirus indicus*[8] (adult).	Fore part of Sternum; side view. . .	do.
20.	Do. (do.)	End of mesosternum; outer view . .	do.
21.	*Manatus americanus*[9] (5 feet 5 inches long.)	Left half of Sternum, with ribs attached; inner view .	$\frac{1}{3}$ nat. size.
22.	*Delphinus*[10] —— ? (embryo 9 inches long).	Right scapula, outer, and Sternum, inner view . .	2 diam.
23.	Do. (do.)	Section of 1st mesosternal .	8 do.
24.	Do. (do.)	Do., showing junction of 2nd rib with Sternum . .	do.
25.	Do. (do.)	Do., showing the joint of 3rd rib	do.
26.	Do. (do.)	Part of fig. 23 . .	16 do.
27.	Do. (do.)	Section showing junction of 5th rib with vertebra . .	8 do.
28.	Do. (do.)	Section of 2nd rib at the sterno-vertebral joint . .	do.
29.	Do. (do.)	Section of lower part of 3rd rib .	do.
30.	Do. (do.)	Part of fig. 25 . .	64 do.

[1] See pp. 219—221. [2] See pp. 219—221. [3] See p. 222. [4] See pp. 219—222.
[5] See pp. 219—221. [6] See pp. 219—221. [7] See pp. 219—222. [8] See pp. 219—222.
[9] See pp. 218, 219. [10] See pp. 217, 218.



Geo West lith. W K Parker del[t] M & N Hanhart imp.

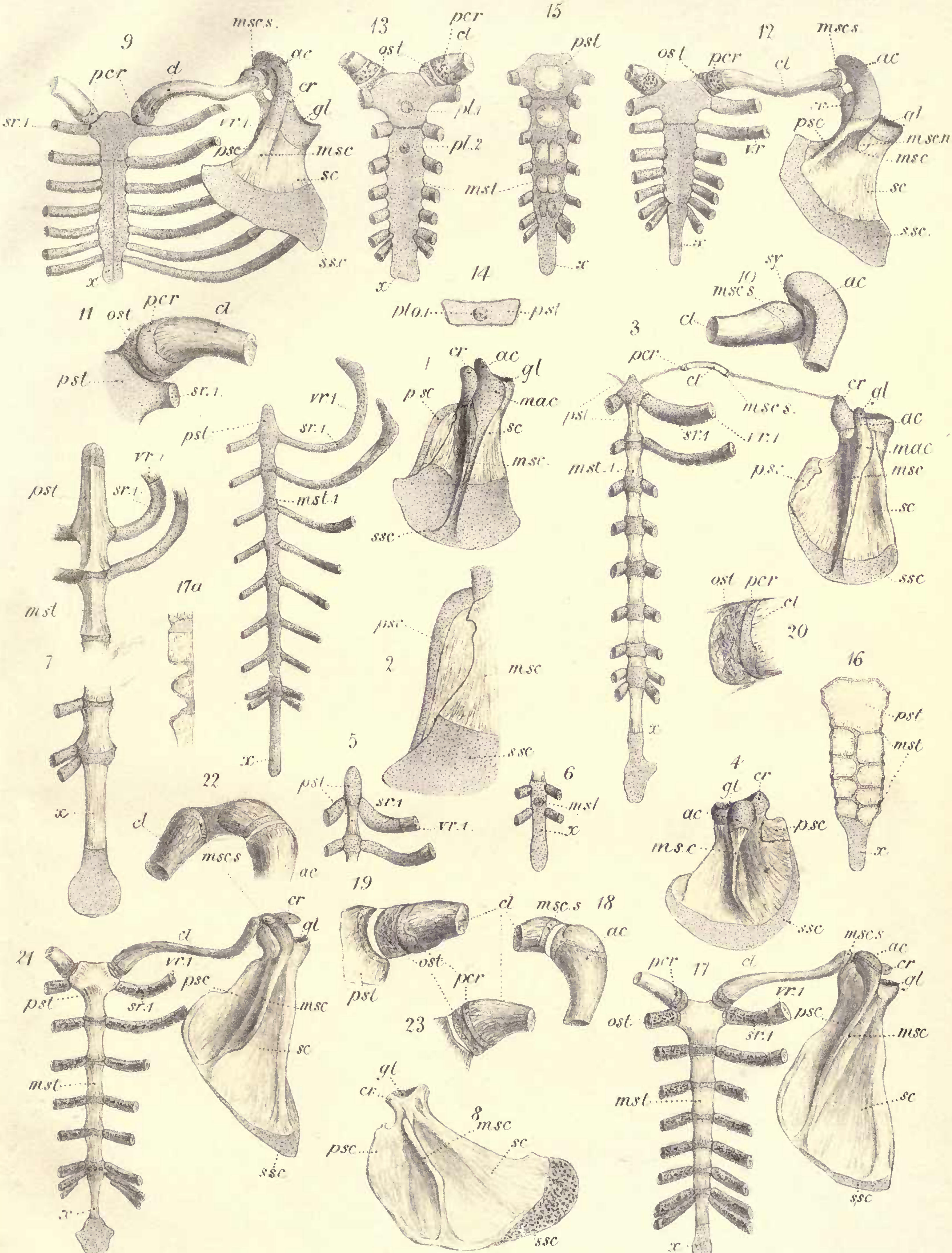
1-5 BOS. 6 TRAGULUS. 7-9 HYRAX. 10-12 SUS.
13-15 EQUUS (*Asinus*). 16 EQUUS (*Caballus*). 17, 18 HIPPOPOTAMUS. 19, 20 TAPIRUS.
21. MANATUS, 22-30 DELPHINUS.

PLATE XXX.

FIG.		SIZE.
1.	*Felis domestica*[1] (2 inches 4 lines long.) Right scapula, outer, and Sternum, inner view	6 diam.
2.	Do. (do.) Part of scapula	12 do.
3.	*Felis varia*[2] (newly born). Right scapula, outer, and Sternum, inner view	$1\frac{1}{3}$ do.
4.	*Thalassarctos maritimus*[3] (at birth). Left scapula; outer view	nat. size.
5.	Do. (do.) Fore part of Sternum; inner view	do.
6.	Do. (do.) Hind part of do. do.	do.
7.	*Otaria* —— ?[4] (adult). Fore and hind part of Sternum; outer view	$\frac{1}{4}$ do.
8.	*Phoca grœnlandica*[5] (do.) Right scapula; outer view	do.
9.	*Homo sapiens*[6] (embryo 2 inches 4 lines long). Right scapula, outer, and Sternum, inner view	4 diam.
10.	Do. (do.) Junction of clavicle with acromion; outer view	8 do.
11.	Do. (do.) Junction of clavicle with præsternum; inner view	do.
12.	Do. ($5\frac{1}{2}$ inches long). Right scapula, outer, and Sternum, inner view	$1\frac{1}{2}$ do.
13.	Do. (7th month, twin). Sternum; inner view	do.
14.	Do. (do.) Section of præsternum	2 do.
15.	Do. (newly born). Sternum; inner view	$\frac{3}{4}$ nat. size.
16.	*Pithecus satyrus*[7] (young). Sternum; outer view	$\frac{2}{3}$ nat. size.
17.	*Cercocebus æthiops*[8] (adult). Right scapula, outer, and Sternum, inner view	do.
17*a*.	Do. (do.) Section of Sternum	nat. size.
18.	Do. (do.) Junction of clavicle with acromion; outer view	$1\frac{1}{2}$ diam.
19.	Do. (do.) Junction of clavicle with Sternum; inner view	do.
20.	Do. (do.) Part of same	$2\frac{1}{2}$ do.
21.	*Jacchus penicillatus*[9] (male, not adult). Right scapula, outer, and Sternum inner view	nat. size.
22.	Do. (do.) Junction of clavicle with acromion; outer view	3 diam.
23.	Do. (do.) Junction of clavicle with Sternum; inner view	do.

[1] See pp. 215, 216.
[2] See pp. 215, 216.
[3] See pp. 215, 216.
[4] See pp. 215, 216.
[5] See pp. 215, 216.
[6] See pp. 222—224.
[7] See pp. 222, 223.
[8] See pp. 222—224.
[9] See pp. 222—224.

Plate XXX



Geo West lith. W.K.Parker del. M&N Hanhart imp.

1, 2. FELIS (*Domestica*). 3. FELIS (*Varia*). 4-6. THALASSARCTOS.
7. OTARIA. 8. PHOCA. 9-15. HOMO. 16. PITHECUS. 17-20. CERCOCEBUS.
21-23. JACCHUS.

m6