ON THE DISPOSITION OF MUSCLES IN VERTEBRATE ANIMALS. BY PROFESSOR HUMPHRY[1].

THE locomotory system of a vertebrate animal consists, fundamentally, of a successional series of alternating transverse skeletal and muscular planes which extend nearly through the outer wall of the animal. I say *nearly* through, for in and around the axial line, and in the immediate mesial plane, this alternation does not exist. The skeletal elements here form a continuous structure composed, in the axial line, during the early fœtal state, and persistently in the Lancelet, of a simple cartilaginous notochordal streak, but usually, at a later period, of cartilaginous or osseous pieces articulated directly together or connected by ligamentous material. This vertebral column extends throughout the whole length of the animal; and cartilaginous or osseous processes run out from it, or in connection with it, more or less transversely, and serve as levers to aid the muscles besides fulfilling other purposes. It is obvious, however, that these processes must, in proportion to their length and unyielding character, limit the range of movement of the axial pieces upon one another and so lessen the flexibility of the animal. Accordingly, in the circumferential regions, especially in the directions in which movement is most required, the skeletal parts are not osseous or even cartilaginous, but are membranous and composed of fibrous plates extending from the axial osseous or cartilaginous structures to the skin. This may be the case throughout the whole of the muscular stratum as in the Lancelet, where the membranous septa extend from the skin down to the notochordal sheath and blend with it. The muscular planes occupy the intervals between the osseous processes and between the fibrous plates, the latter being continuous with the osseous axial pieces and their processes.

[1] The anatomical points mentioned in this paper, unless otherwise specified, are all from notes, published in the *Journ. of Anat.*, or in manuscript, of dissections made by Mr Anningson or myself. I have not been able to investigate the now copious literature of the subject so much as I could have wished.

This arrangement is found most distinct in the simplest parts of the lower vertebrates, as throughout the Lancelet and in the caudal region of Fishes and Urodelans. The structure of that region, with its longitudinal divisions caused by the dorsal, neural and lateral septa, and its transverse divisions caused by the transverse septa, has been described in the Cryptobranch (p. 3)[1].

The transverse skeletal planes, membranous, cartilaginous and osseous, are sometimes called 'sclerotomes' and the trans-

[1] I should observe that the angular spaces left between the longitudinal divisions are not always, as in Cryptobranch, occupied by fat. In the Fish the dorsal and ventral furrows are often partly occupied by the dorsal and anal fins (see pp. 256, 277); and the lateral furrows are commonly occupied by muscular fibres which bear the transverse septa, but which are more closely connected with the skin, and peel off with it more easily than the rest of the lateral muscle. These fibres are more vascular than ordinary muscular fibres; and in a piece which I examined from a Dace they contained more oil than the other muscles. Stannius (*Handbuch der Zootomie*, II. 112) says that they, in addition, present microscopically the appearance of tissue in process of conversion into muscle. I did not find that to be the case. With the exception of the excess of oil, they presented the usual microscopical characters of striped muscle.

Stannius (II. 93) uses the terms 'epaxonisch' and 'hypaxonisch' to indicate the muscles above and below the axial vertebral line. Huxley (*The Anatomy of Vertebrate Animals*) uses the terms 'episkeletal' and 'hyposkeletal' to indicate the muscles situated respectively above and below the endoskeleton, and developed from above and beneath the protovertebræ. Strictly speaking, however, all the muscles are *interskeletal;* forasmuch as the intermuscular septa extend, from the transversalis fascia to the skin, through the entire thickness of the muscular layer which appears to be primarily and essentially one, and which is, for aught we know, all developed from the same embryonic protovertebral stratum; and the skeletal tissues undergo chondrification and ossification in certain parts only and in certain planes. The parts in which these changes take place are chiefly in and near the axial line. The plane in which chondrification and ossification occur is almost exclusively the middle one; and ossification without chondrification—i. e. from membrane—is most frequent in the superficial muscular plane; though it may take place much deeper, as in the instances of the parasphenoid, or sub-basal, bone and the vomer. I am not here speaking of the epidermal, or superficial dermal, tissues which may also be changed into horny matter, cartilage or bone. The ossifications in this epidermal layer are as distinct from those in the outer, or subcutaneous, muscular plane as these are from the chondrifications and ossifications in the middle muscular plane, or more so; and I do not think this distinction has been quite sufficiently kept in mind. It must not be forgotten that the 'cartilaginous,' the 'membranous,' and the 'epidermal' ossifications may be blended, and that the two former are particularly liable to be so. Indeed, those that begin in cartilage are usually enlarged by the addition of membrane bone. Histologically, there is perhaps no essential difference between the two.

It is, I think, far better to reserve the prefix 'epi' to designate the bones—membrane bones—which are formed, usually, though as above mentioned not always, in the superficial muscular or subcutaneous strata, and thereby distinguish them from the subjacent cartilage bones with which they are often closely related. Thus the 'episternals' and the 'epicostals' are indicated to be bones found in the tissue overlying the sternum and the costæ; and the 'epicoracoids' are bones or bony plates formed over, or upon, perhaps blended with, the coracoids.

verse muscular planes between them 'myotomes.' Very rarely, however, are the planes truly transverse. They commonly slant with more or less obliquity, backwards or forwards, from the axial line towards the circumference. An additional and more perplexing element of confusion is imported by the membranous or fibrous portions of the sclerotomes—the intermuscular septa as they are called—not preserving a uniform direction, but slanting first one way then another, first backwards and then forwards, or vice versâ, as they are traced from the upper or dorsal edge of the animal. Thus they acquire a more or less waving or zigzag line; and their superficial margins come to deviate considerably from the lines of their deeper margins and the lines of the osseous vertebral processes to which they are attached. Moreover the several curves or angles so formed may be produced to a great length. Especially is this the case near the mesial line, above—in the 'mesio-dorsal' part of the lateral muscle. Here the angles of the septa are often prolonged to a considerable distance; and in some Fishes (Bream and Dog-fish) they are, near the surface, thickened into tendons with the muscular fibres on the two sides of each passing obliquely between it and the adjacent septa, which has the effect of allowing the traction of a large number of muscular fibres to be brought to bear upon a given point or points (p. 271, Fig. 28). Where this occurs the intermuscular septa cease to run directly into the skin or to retain their close connection with it; for the cutaneous terminal filaments become converted into loose areolar tissue. Hence the tendinous septa as well as the intervening muscular planes, near the dorsal median line, in the Fishes above mentioned and in others, are allowed to glide with greater freedom beneath the skin than are the more lateral and ventral muscles, which are bound to the skin by the intermuscular septa running from the axial osseous structures into it.

A further change consists in the isolation of the prolonged and tendinous superficial parts of the septa from one another, and, to a greater or less extent, from their muscular contingents, as well as from the deeper and the superficial structures; so that they run alone to their destinations and admit of traction without hindrance. This is effected by the conversion of the surrounding connecting structures into loose tissue, as just mentioned in the case of their isolation from the skin. Such a condition we find developed to perfection in the numerous delicate muscles and tendons which lie along the sides of the dorsal spinous processes of Snakes.

Thus, by comparatively simple stages of transition, the elongated longitudinal dorsal muscles are brought into relation with, or reduced from, the simple primary transverse muscular strata; and it is to be remarked that while this change takes place, usually in some degree and in many instances to the extent I have mentioned, in the upper or 'mesio-dorsal' part of the lateral muscle, the transverse disposition is commonly maintained through the visceral region, at any rate in the opposite and lowest, or 'mesio-ventral' part of the same muscle. Witness the transverse direction of the septa when they are persistent in the *rectus abdominis* and in its extensions into the neck and the tail.

So much for the variations in the fibrous plates or septa of the skeletal structure. Then, with regard to the muscles between them. These, in the simple condition, occupy the intervals between the septa and are composed throughout of fibres passing, antero-posteriorly, from one septum to another. Through the medium of the septa the fibres of one compartment are connected with those of the adjacent compartment, and also with the subcutaneous fascia and the skin, as well as with the osseous structures of the skeleton and the internal or transversalis fascia. I have already mentioned that where the septa are very oblique the muscular fibres between them usually take an oblique direction also.

Sometimes the fibres at one part of the thickness of the lateral muscle take an oblique direction different from those at another depth. This alone is sufficient to cause a cleavage into planes; and the cleavage usually extends through the septa as well as between the muscular fibres, so causing the separation of one or more superimposed muscular sheets which are thus rendered capable of moving upon one another[1].

[1] The cleavage of a muscle into two planes, in consequence of a difference in the direction of its superficial and deep fibres, is well illustrated in the *pectoralis*

The Cryptobranch (p. 10) and the Lepidosiren (p. 256) offer examples of the cleavage being confined to the muscular elements without involving the septa. When the cleavage involves the septa these may remain (p. 258). Commonly they disappear, more or less completely, throughout the thickness of the muscular substance. A continuity, or ankylosis of the muscular fibres of the several compartments is thus established; and all trace of the primary, transversely segmented, myotomic arrangement is obliterated[1].

Even without an alteration in the direction of the muscular fibres a cleavage into superficial and deeper planes may take place; and it may take place completely or partially. Thus a superficial stratum of muscular fibres, having the same or a different direction from those beneath them, may be quite severed from the deeper strata. It may retain here and there connection with the skin only, so forming, as is the case with portions of the pannicle, a purely 'cutaneous' or as commonly designated 'subcutaneous' muscle; or it may retain, at one or more places, a connection with the deeper strata of the muscle or, through remnants of the transverse septa, with the osseous skeleton. Thus it may be, as numerous varieties of the pannicle shew, a 'musculo-cutaneous' or 'osseo-cutaneous' muscle[2]. Lastly, a given layer may be severed from the deeper strata in a part only of its length, and may retain a connection, through the septa, which as already mentioned are equivalent to tendons, at both ends, either with the subjacent muscle or with the subjacent skeleton; witness some of the dorsal muscles, the muscles passing to the girdles, and many others. That is to say, a superficial or cutaneous stratum may be segmented more or less completely from the rest of the muscular system; and various strata of

major of Cyclothurus (*Journ. Anat.* IV. 25), and still better in that of the Wild Cat, in which there are no less than four layers.

[1] This is exemplified even in the Myxinoid fish Bdellostoma; and the contrast between the absence of inscriptions, or '*ligamenta intermuscularia*,' in the oblique muscles, and their presence in the straight muscles, is well shewn in Tab. I. accompanying Müller's well-known paper, *Abhandl. Berlin. Akad.* 1834.

[2] In Pteropus (*Journ. Anat.* III. 299), the cutaneous muscles are connected with the skull, the sternum, the coracoid, the pelvis, and the femur, thus presenting unusually numerous and good examples of 'osseo-cutaneous' muscles. They are also remarkably well developed and have several osseous connections in the Hedgehog.

the remaining deeper portion may be more or less completely segmented from each other.

It is a very common thing for the muscular fibres to miss, that is, to pass over or under, one or more septa, as in the case of the erector spinæ and the subcostals. In these instances, and others of the like kind, the muscular fibres are continued through, or are ankylosed through, the septal tissue which has disappeared as such, owing to the embryonic tissue of the intermuscular septa undergoing the same histological change as the muscular parts. See p. 301.

A muscular plane, or any part of it, may also be divided longitudinally into portions or sectors by cleavages similar to that by which itself was separated from the strata above or beneath it.

Thus from the simple primary, transversely segmented, lateral muscle, on either side of the animal, the various muscular forms may be elicited. Moreover the differences in the muscular systems of different animals, and in different though serially homologous parts of the same animal, may in great measure be explained by variations in the number of the strata or of the sectors, or by variations in the depths at which the several strata have been detached, or in the points at which the several sectors have been separated. Hence, although general correspondence may be indicated, precise homology must not be too closely pressed.

The processes which I have mentioned may be recapitulated as follows: 1, varieties in the inclination and direction of the septa; 2, prolongation of the angles of the septa caused by increased inclination and flexure; 3, separation of the thus prolonged septa with their appended muscular fibres, individually or in groups, into independent muscles; 4, variation in the direction of the muscular fibres; 5, cleavage into planes and into sectors reaching to various depths; 6, fusion or ankylosis of the muscular segments by the establishment of continuity through the septa.

In the three highest orders of vertebrates, if we exclude the vertebral processes, the ribs, the hyoid and the limb girdles, which are ossifications in the deeper parts of the septa, and the tendons of the dorsal muscles, which are modifications of the septa, the intermuscular septa are represented only, or chiefly, by the inscriptions in the *rectus abdominis, biventer cervicis, digastric* and *omo-hyoid,* by occasional inscriptions in the *sterno-hyoid* and *sterno-thyroid,* by the clavicle or the inscription which, in carnivora and some others, is substituted for it between the *trapezius* and the *deltoid,* and by Poupart's ligament.

The fibres in these animals retain their simple antero-posterior direction between the successive skeletal septa in the instances of the *interspinales* and *intertransversales* and in the *recti-abdominis,* though in the last some of the septa have been obliterated. In the *semispinales* the fibres run obliquely between the successive skeletal structures and also in the *intercostales.* In these last, the direction of the obliquity varying at two parts of the depth between the successive ribs, two strata are formed resembling the two strata of external and internal oblique between the successive ribs and septa in the abdomen of Cryptobranch (p. 10). These and other variations will, however, be mentioned as we proceed.

Reverting to the plan of the construction of the locomotory system of a vertebrate animal, we have found it to consist of a series of transverse, alternating, skeletal and muscular planes or discs, traversed by an antero-posterior axial line, the whole being enclosed in an external fascial sheet which is also part of the skeletal system and which lies beneath the skin. A transverse section shews that each disc is in two lateral halves applied, as it were, upon the axial line which is formed by the notochord or the vertebral bodies. Each half constitutes one side of the animal. Owing to the obliquity with which the planes or discs slant from the axial line, a transverse section passes through both the muscular and the skeletal planes and shews their relative disposition. Such a section indicates the locomotory system of an animal to consist on each side of a fascial, or skeletal, tube enclosing a muscular cylinder, which last is traversed by transverse or oblique, fascial or skeletal planes. The approximated sides of the skeletal tubes are flattened against each other, above and below the axial line; and becoming fused here in great part of their extent they form mesial septa passing, dorsally and ventrally, from the axial line.

This is well illustrated by the section of the tail of a Tadpole (Fig. 41)[1], in which the fascial walls on either side, ascending and descending from the notochord and enclosing the neural and hæmal canals, meet and so form the dorsal and hæmal septa. These run peripherally into the upper and lower membranous edges of the tail, where they are joined by the fascial layers from the exterior of the lateral muscle. Thus each membranous edge of the tail is composed, essentially, of four sheets —the two mesial sheets which are blended together and form the septum, neural or hæmal, and the two external, or lateral, sheets which are derived from the superficial covering, or fascia, of the lateral muscle. It is interesting to observe that at the

[1] The specimens of Pseudis Tadpole, from which the drawings were made, were kindly sent me by Mr Mivart.

Description of Figures of the Pseudis Tadpole (Pl. XV.).

Fig. 39.—Side view of the animal, shewing the lateral muscle of the tail. This at the hinder part is in interrupted fragments, which are serially arranged in rows with wide septa between the rows. Further forwards the muscular fibres are more developed, filling in the rows and diminishing the intervals between them. A pin (*C*) is placed in the cloacal opening; another, above *B*, is in the branchial opening. Above, and in front of the branchial opening, is the eye. The small hind limb is seen on the hinder wall of the visceral cavity, or rather in the furrow between it and the tail, above *L*.

Fig. 40.—The visceral cavity laid open in a specimen more advanced where the cavity is more elongated. The transversely marked ventral portions of the lateral muscle are seen extending, from the tail, along the sides of the bodies of the vertebræ, and projecting into the visceral cavity, with an interval between them leading down to the hæmal passage which has ceased to be a covered canal, and is merely a channel. The wall of the visceral cavity has been turned back; and the commencing development of its muscle is shewn, in isolated tracts, by fine muscular fibres arranged in rows between broad, white (septal) lines.

Fig. 41.—A transverse section at about the middle of the tail. The large central circle is the notochord, with a small neural canal above and a small hæmal canal below.—*D. F.*, the dorsal, or neural, membranous fringe.—*V. F.*, the ventral, or hæmal, membranous fringe. The neural septum extends from the notochord up the middle of the one, and the hæmal septum down the middle of the other. The sides of both are formed by extensions of the membrane covering the lateral muscle. The base of each, between the mesial septum and the external membrane, is occupied by soft succulent tissue which is separated from the lateral muscle by an offset from the external enveloping membrane.

Fig. 42.—A section through the animal, made at the back part of the visceral cavity, and seen from in front. *D. F.*, the dorsal fringe with the neural septum descending, through its middle, to the neural canal and the notochord. Beneath the latter is the hæmal passage at the bottom of a deep channel between the lateral muscles of the two sides, or, rather, between the plates of the hæmal septum, which have not coalesced, and which separate the hæmal channel from the lateral muscles. Beneath this channel is, *C*, the cloacal tube. *A* is the wide posterior cul-de-sac of the abdominal wall, with the muscular fibres beginning to be developed in rows between the paler lines, which indicate the future septa.

Fig. 43.—A section farther forwards. *A*, the abdominal, or visceral, wall ascends, is reflected, higher on the sides of the lateral muscle, reaching to the dorsal part of that muscle. The hæmal channel is wider and forms part of the visceral cavity.

extremity of the tail (Fig. 39), as well as along its upper and lower edges, the membranous sheets alone exist, the muscular fibres being absent; so that the mesial and external membranous plates are in contact. A little in front of the extremity of the tail the muscular fibres begin to appear, in patches, separating the external from the mesial plates. The patches are in broken rows; still they succeed one another in serial order. Gradually, as they are traced forwards, the rows are filled up and the membranous interspaces between them become reduced to the narrow intermuscular septa; while the muscles, increasing in thickness, acquire the semicircular or ovoid form which is seen on either side of the median line in a transverse section (Fig. 41). It is thus perceived that the membranous, or intermuscular, element is the first formed, that the muscular fibres are produced, or added in it, that the intermuscular septa and fascial sheets are remnants of it, and that these give way, in greater or less degree, before the force of muscular development.

Usually, in other animals, ossification takes place, to a greater or less extent, around the notochord, giving rise to the bodies of the vertebræ, and extends into the ascending and descending mesial laminæ, forming the neural and hæmal arches and spines. In Fishes (Figs. 31, 32 and 33) it also often extends into these laminæ, where they stretch, like the membranous fringe of the Tadpole's tail, beyond the confines of the lateral muscle. Thus are formed the fin-ray bones, which, like the septa, are double, actually or potentially; and muscular fibres are formed upon them. These have the same relations to the membranous laminæ, and the same segmentation, as the fibres of the lateral muscles, and are, indeed, extensions of them, though they take a different direction, and are, consequently, segmented from them (p. 257).

In front of the tail, in the visceral region, the mesial hæmal laminæ are kept apart; and the visceral cavity is formed between them. In other words, they are spread out over it, and form the *fascia transversalis*. This separation of them may, in the hindmost region of the visceral area, be confined to the marginal part of the hæmal septum: thus, in Fig. 39 of the Tadpole, the cloacal tube and aperture are seen to lie at the junction of the membranous caudal fringe with the abdomen; and they are the result of a want of adhesion of the mesial laminæ which form that fringe. In the Fish the cloacal fissure, or separation, of the mesial laminæ, usually extends deeper into the region of the hæmal spines, which are, accordingly, bifurcate and arch transversely over this part of the visceral cavity instead of, as in the tail, occupying a median position, and each pair being fused into a single process. In front of the cloacal region, and through the rest of the visceral cavity, with occasional exceptions near the head, the separation of the mesial laminæ extends down to the vertebræ, splitting the hæmal arches of the two sides quite asunder, and laying the hæmal canal open to the visceral cavity. Towards the fore part of the visceral cavity the mesial laminæ and the hæmal arches are pressed so far upwards upon the vertebral bodies that the arches come to occupy the place of ribs.

The wall of the visceral cavity is thus formed by the separated and expanded hæmal plates, and not merely by those parts of the plates upon which, in the tail, the lateral muscle is formed, but by those parts also which form the membranous hæmal fringe in the Tadpole's tail, and in which the subcaudal or anal fin is formed in the Fish. In the Tadpole it is chiefly this latter, membranous, fringe-like part which becomes expanded; for the lateral muscle (the ventral portion of it) is continued, without much alteration, from the tail, forwards, through the abdomen[1], as represented in Figs. 40, 42 and 43. These figures further shew the manner in which the membranous part is spread out and is reflected upon the sides of the lateral muscles, so as to give greater space for the contents of the visceral cavity; and they shew the mode in which the development of the abdominal muscles is commencing in the thickness of the wall by broken serial rows of muscular fibres with intervening septal lines, upon which the muscular transformation gradually encroaches, in the same manner as the development of the lateral muscle is progressing at the end of the tail (Fig. 39). Further, in Fig. 40, an extension from the sides of the lateral muscle is seen to be proceeding into the hinder part of the abdominal wall. In the Fish, the part of

[1] It is reduced and becomes the *quadratus lumborum* in the Frog.

the hæmal plate in which, in the tail, the lateral muscle is developed becomes, in the abdomen, more expanded than it does in the Tadpole, and forms, at any rate, the ventro-lateral (*V. L.*, Fig. 31) portion of the body-wall. It is not improbable that the part in which, in the tail, the anal sub-caudal fin is developed is continued forwards into the abdomen as the mesio-ventral (*M. V.*, Fig. 31) portion of the body-wall. Of this, however, I cannot be sure, the two parts (*V. L.* and *M. L.*) being, as we might expect from their development in one continuous hæmal plate, blended into one 'lateral' muscle[1]. There can, however, be little doubt that, as pointed out by me, in a paper "on the Homology of the Mesial and Lateral Fins of Fishes," in this *Journal*, Vol. V., the ventral and pectoral fins and their muscles are formed from the same serial elements as the sub-caudal or anal fins and their muscles.

I will now consider, briefly,

THE DORSAL MUSCLES OF THE TRUNK,

that is, the muscles situated above the lateral septum. These, though numerous, in accordance with the number of the vertebræ that require to be moved upon one another, do not present much variety or much interest in different animals. In the Fish the dorsal mass from which they are derived indicates a division into an upper or 'mesio-dorsal' and a lower or 'latero-dorsal' part. This division corresponds on the whole with that into the *spinalis* and *longissimus dorsi* and the *sacro-lumbalis* parts in higher animals. Such incipient longitudinal segmentation is less marked in Cryptobranch, Perennibranch, and Lepidosiren, than it usually is in Fishes. It is seen again in the Salamanders.

The dorsal muscles may be arranged, as follows, in two divisions:

First, those in which the fibres retain the primary antero-posterior direction and pass between corresponding parts of contiguous or distant vertebræ. Those connected with contiguous

[1] Supposing this view to be correct, the sternal ribs and the sternum would be serial representatives, not of the hæmal processes but, of the osseous elements of the subcaudal fin—the fin ray-bones—of the Fish.

vertebræ are commonly designated in accordance with the parts of the vertebræ between which they pass. Thus they are called '*Interspinales*', '*Intertransversales*', and '*Interobliqui*' or '*Interaccessorii*'. The foremost of them is the *Rectus capitis posticus minor*. They are developed in proportion to the mobility of the parts between which they pass, that is, they are most developed in the neck and loins, and least in the back. In the back the *intertransversales* and *interspinales* are sometimes merely ligamentous. In the more superficial members of this series the fibres sometimes leap over one or more segments to a distant point. This is caused by the superficial fusion of two or more septa, owing to the non-development of muscular fibres between them, or by the superficial obliteration of one or more septa from the extension of muscle-development through them, producing, in the one case, an elongation of septum or tendon, and, in the other, an elongation of muscle. In this manner are formed the *spinalis dorsi* and *spinalis colli* and the several parts of the *erectores spinæ*. The last, it may be observed, often overlap, to some extent, and are connected with the ventral parts of the skeleton, viz., the iliac bones and the ribs, parts, that is, which lie beneath the lateral line.

The *second* division includes the muscles in which the fibres have an oblique direction and pass between non-corresponding parts of contiguous or distant vertebræ, for instance, from transverse process to spine, or from spinous process to transverse process. The obliquity is therefore in two directions, giving rise to two sets, the fibres of which cross one another. In the one set the fibres pass from spinous processes *out*wards and forwards to the transverse processes; and in the other set, which is on the whole in a deeper plane, the fibres pass from the transverse processes *in*wards and forwards to the spinous processes. The more superficial, spino-transverse or *out*wardly directed, set comprises the *obliquus capitis inferior*, and the *splenius capitis* and *colli*. The deeper, transverso-spinous or *in*wardly directed, set comprises the *obliquus capitis superior*, the *complexus* with the *biventer*, the *semispinalis colli* and *dorsi*, the *multifidus* and *rotatores spinæ*.

The dissections of Cryptobranch (Fig. 20) and of Lepidosiren (Fig. 25) show conclusively that the *temporal* muscle is a prolongation of the dorsal muscle forwards from the neck, beside the cranial neural arches, over the suspensorium, to the lower jaw, and that the temporal fascia is the continuation of the fascial aponeurosis of the dorsal muscle. They render it probable that the *masseter* and *external pterygoid*, and also the ocular muscles, are an extension of the same series. According to this view the temporal ridge which, in most vertebrates, shuts off the masticatory muscles from the rest of the dorsal system, may be regarded as an ossification of, or an ossification extending into, a transverse intermuscular septum, an ossification, that is, in the superficial stratum of the dorsal muscle passing upon the head.

The *ligamentum nuchæ* and the interspinous ligaments, as well as the ligamentous bands tying the skin to the several spinous processes, are modifications of the longitudinal median septum which I have already (pp. 254, 300) described.

The modifications of the dorsal muscle in the tail do not require any special description. It may be sufficient to remark that in cases where the pelvis is absent or rudimentary, as in the Porpoise, the portion of it called *erector spinæ* is continued uninterruptedly from the lumbar to the caudal region.

The Ventral Muscle

is subject to much greater modifications in the different regions of its course than is the dorsal. In the hinder part of the tail it much resembles the dorsal muscle of the same part; but, anteriorly, the symmetry between the muscles above and below the lateral line is destroyed by the expansion of the ventral muscle over the visceral cavity, by the formation of the limb-girdles in its substance, and by its relation to the limbs. Travelling forwards it first comes into relation with the openings of the alimentary, urinary, and genital organs, and detaches muscles to them. It then encounters the pelvis and hind limb, which, more or less, interrupt and make demands upon it. Next it is expanded, and the direction of its fibres is modified, by the visceral cavity. Then the shoulder-girdle and fore-limb, the branchial and hyoidean apparatus, the larynx and pharynx, the lower jaw and the face necessitate modifications to meet their several requirements, which vary in different animals, and which lead to almost infinite diversities in the disposition of the several parts of the muscle.

The ventral muscle, and this is important, not unfrequently overlaps the dorsal muscle. Such is described by Müller to be the case in Bdellostoma[1]; and superficial fibres or strata of it are often prolonged into the tissue over the dorsal muscle, so reaching the dorsal spines, or are continued as distinct muscles to this region (see pp. 13, 260, and Fig. 24). This occurs especially towards the fore part of the trunk, and is exemplified particularly in Snakes (Fig. 44); and this extension contributes to the formation of the superficial muscles of the neck, throat and face, as well as to those of the limb-girdle and limb.

While the superficial strata of the ventral muscle thus overlap the dorsal muscle, and reach to the dorsal median line, the deeper strata, as represented by the intercostals and the ribs, are commonly, to some extent, overlapped by it; so that the lateral margin of the dorsal muscle is received between the layers of the ventral muscle.

In the simplest condition, as in the ordinary teleostean fish, the ventral muscle does not undergo much change in its different parts. The two fascial hæmal plates, as has just been shewn, which line the apposed sides of the ventral muscle, in some parts of the tail coalesce beneath the hæmal spines, and form a median osseo-membranous septum, extending from the hæmal spines to the skin. At other parts they are separated by the caudal or anal fins. At the foremost part of the tail they are also separated; and the commencement of the visceral space exists between them, but walled off from the hæmal space by the hæmal arches still bridging over the latter. Further forward the separation is greater, the osseous hæmal arches disappear, the hæmal and visceral cavities are laid into one, or are divided only by membrane. The ventral muscles of the two sides are pushed asunder; and the separated membranous hæmal plates which line them are named the *fascia transversalis*. Ossifications in the inner parts of the transverse septa which pass from the fascia transversalis, through the lateral muscle, to the external fascia and the skin, form the ribs.

[1] *Abhandl. der Akad.* Berlin, 1834, s. 245. It may be observed also that in Bdellostoma (*l.c.* p. 246) the superficial fibres of the ventral muscle, in the interval between the head and the hinder opening of the gills, cross the median line and are continued from either side upon the surface of the ventral muscle of the opposite side, where they are lost in the superficial fascia. This, however, is quite exceptional.

The latter thus correspond serially, or nearly so, to the hæmal spines, split and pressed asunder, and to the sides of the hæmal arches. If an interval is left between the ribs and the transversalis fascia, in which muscle is developed, it constitutes the *transversalis* muscle, or it may constitute the *levatores*, or, more commonly, the *depressores costarum*, according to its position[1]; and when this muscular sheet extends beneath the bodies of the vertebræ it constitutes the *subvertebral rectus* (p. 11).

The mesial edges of the ventral muscles, inferiorly, are separated and covered by *fascia transversalis* continued round each into the *external fascia*. Behind, there is an interval between the contiguous edges of the ventral muscle, thus covered by fascia, which permits the passage of the alimentary tube to the anus. A layer of the fascia (Fig. 23, *G*) accompanies the tube and binds it to the skin; and some muscular fibres may be developed around it forming a sphincter.

In front of the anus the pelvic bones lie between the *fascia transversalis* and the ventral muscle, or in the substance of the deeper layers of the ventral muscle, in the same plane, that is, as the ribs. The fins project between the mesial edges of the ventral muscle; but marginal portions, or (Bream) a larger amount of the deep stratum, of that muscle are attached to the pelvic bones, constituting a '*retractor*' or '*protractor*'; and more superficial portions constitute what are sometimes called '*carinales*' muscles. In some Fishes (Ceratodus) portions of the ventral muscle extend upon both surfaces of the fin. The pectoral fin projects at a more lateral point; and the ventral muscle is attached more largely to its girdle which, like the pelvic bones, occupies the same relative position, with reference to the thickness of the abdominal wall, as the ribs. From it the ventral muscle is continued forwards to the hyoid and the head.

[1] In the Bream, Dace, and some other Fish, there is a sheet of muscular fibres passing from the vertebræ forwards and downwards internal to the ribs, that is, taking a direction corresponding to the internal intercostals and subcostals of mammals, and to the internal intercostals, *depressores costarum* and *transversalis* of Cryptobranch. In Ceratodus (p. 280) I have described tendinous fibres taking the same direction. Some are attached to the ribs nearest to their point of origin, others to more distant ribs. The nerves are external to this sheet. Towards the fore part of the body of the Dace fibrous bands take the place of these subcostals.

The median third or half of the ventral muscle is not unfrequently distinguished from the remainder in Fishes by the mere transverse direction of its septa. In some, as the Dogfish (Fig. 28), it is segmented from the remainder, in great part of its extent, and overlaps it. In Mammals also it is separate, as *rectus*, and is enclosed in a sheath formed by prolongations of the lateral portions of the ventral muscle, or their tendons, to the mesial line. Its continuity with the lateral parts of the ventral muscle has been shewn in Cryptobranch (p. 11), and in Lepidosiren (p. 256). In Cryptobranch, however, it must be observed that while the more superficial or *oblique* strata of the ventral muscle are continued into the *rectus*, the deepest or *transversalis* stratum, separating itself from the others, passes upon the deeper surface of the *rectus* to the middle line; and in Mammals the *rectus* is ensheathed by tendinous extensions from the deep, or peritoneal, and the superficial, or cutaneous, divisions of the ventral muscle which pass, upon its peritoneal and cutaneous surfaces, to the middle line. Though we are in the habit of thus referring the walls of the sheath of the *rectus* to the expansions of the lateral parts of the *ventral* muscle, we may, with equal right, assume them to be deep and superficial strata of the *median* part of the ventral muscle, that is, derivations from the *rectus* itself. And as, on the one hand, they retain their continuity with the lateral parts of the muscle, so, on the other hand, do they retain their connections with the *rectus*, or middle stratum of the same, through the transverse inscriptions which extend from it into them.

As already intimated the ventral muscle is disposed in three chief planes or strata which are in variable degrees distinguishable in different animals and in different parts of the same animal. Of these, the middle—or internal oblique—plane is that in the septa of which the pieces of the true or cartilage skeleton are for the most part developed: the external—or external oblique—stratum is connected with the external fascia and the skin, and is that in which the pieces of the dermal or membrane skeleton are for the most part developed: and the internal—or transversalis—plane is connected with the internal or transversalis fascia and the viscera, much in the same way as the external plane is connected with the external fascia and the skin. The connection with the viscera, however, is in great part interrupted by the formation of the visceral cavity. Primarily all the planes are continuous or, rather, formed one plane from the skin to the visceral tube. It remains so in the Leech. In the Earthworm the transverse septa still connect the visceral tube and its muscles with the dermal sheet and its muscles. In higher animals the visceral cavity interrupts the septa; and they are restricted to the dermo-muscular layer, except near the oral and anal apertures, and in the situation of the diaphragm or diaphragms, where the inner layer or layers of the dermo-muscular sheet bend in towards and come into contact with the visceral sheet of the animal. In the Fish the dermo-muscular sheet is, for the most part, in one undivided plane, with the septa extending throughout it and connecting the skin with the fascia transversalis. In Batrachians the muscular part is more separate from the skin on the one side, and the fascia transversalis on the other; and the stratification of the muscular part into the three planes above-mentioned is commencing.

We will first take the INNERMOST—the TRANSVERSALIS—STRATUM of the ventral muscle, the stratum that lies internal to or beneath the osseous skeleton, or between the innermost parts of the skeleton, and internal to the chief nervous and vascular trunks. In most Fishes (though not in all, p. 307) it is absent, or partial or rudimentary, being represented by tendinous or fascial structures and scarcely distinguishable from the *fascia transversalis*. It may enter with that fascia into the formation of the *post-cardiac diaphragm;* and it is sometimes (Dog-fish) a main constituent of the *pre-cardiac diaphragm.* In Cryptobranch we have found it very extensively disposed beneath the ribs and the rest of the wall of the abdominal cavity, forming the *depressores costarum* and the *transversalis* muscle. It also lies beneath the vertebral column, from the pelvis to the head, forming the *subvertebral rectus;* and there is no *diaphragm.* In higher animals it seldom is present as a continuous sheet in this last situation; but portions of it remain, forming the *longus colli,* the *rectus capitis anticus,* the *crura* of the *diaphragm* and the *retractor ani.* On the interior of the lateral parts of the abdomen and thorax it is usually present in animals above Fishes, forming the *transversalis* muscle and the *depressores costarum*[1], also the internal *intercostals* and the *triangularis sterni*[2] with the *subcostals.* It is continued, with more

[1] These last are strongly developed in Snakes, and are quite segmented from the *transversalis* with an interval between them and it, in which the *levatores costarum* appear.

[2] The *triangularis sterni* and the *transversalis* are sometimes continuous in Man, as remarked by Stannius, Rosenmüller and Meckel.

or less interruption, within the pelvis and is then gathered in around the bowel as a pelvic diaphragm, or *levator ani*, some of its fibres being reflected into, and some continued into, the muscular coat of the bowel. In some instances—Pseudopus P. (p. 289), Cryptobranch (p. 17) and others—a part of it is continued on into the subcaudal muscles. In Mammals a stratum is inflected from the ribs, or gathered in like the *levator ani*, upon the alimentary tube, forming the lateral portions of the post-cardiac *diaphragm* which, in continuity with a remnant of the subvertebral portion (the *crura*), constitutes a septum shutting off the thoracic from the abdominal regions, but with apertures, like those in the pelvic diaphragm, for the passage of the œsophagus and the vascular and neural trunks. The *psoas magnus* and *parvus* also appear to be derivatives from this stratum[1], as well as some fibres of the *cremaster*.

It will be evident that the direction of the fibres of this stratum varies much in different parts of its extent, being antero-posterior where it lies under the vertebral column, oblique where it lies under or between the ribs, transverse where it forms the abdominal wall, and converging where it is inflected upon the viscera; and in proportion to the diversity in the direction of their fibres the several parts are segmented from each other.

In Cryptobranch it is throughout, or nearly, traversed by septa, and is so held in continuity with the *transversalis fascia*, on the one side, and the rest of the ventral muscle and the components of the osseo-cartilaginous skeleton on the other. In higher animals, however, the septa for the most part disappear in its substance and upon its surfaces. They still abide forming the lines of separation between the digitations of the *transversalis* muscle and the *diaphragm*, as well as between the members of the internal intercostal series, blended in the latter situation with the costal periosteum or perichondrium.

The *internal* or *transversalis fascia* is in contact with the greater part of the extent of the internal surface of the transversalis stratum and is gathered in with it to form the *levator ani* and the post-cardiac diaphragm. Thus it lies upon the anterior

[1] In the Guinea Pig the *psoas parvus* passes with the *ps. magnus* and the *iliacus* over the pubes to the lesser trochanter of the femur.

and posterior surfaces of both those diaphragms and reaches and is continued upon the alimentary tube[1]. From the anterior surface of the *levator ani* it is reflected upon the rectum and the bladder; and from the posterior surface it is continued to the integuments of the anus and the superficial fascia of the perineum. The part of the internal fascia behind the gathering-in of the *levator ani* forms the true pelvic fascia lining the obturator muscle; and it is stretched beneath the pubes as the triangular ligament. The part of the internal fascia in front of the diaphragm lines the intercostals and the ribs and is gathered in, in front of the first rib, as the precardiac diaphragm, or the deep cervical fascia, between the thoracic and the cervical regions. The internal fascia is also continued upon the inner surface of the cremasteric projection of the transversalis muscle, forming what is called the *fascia propria* of the spermatic cord. Just in front of the pubes, in Man and some other animals, the internal fascia is separated from the *transversalis* muscle which there passes with the internal oblique in front of the *rectus*.

The MIDDLE—the INTERNAL OBLIQUE—STRATUM is the most persistently intra-skeletal of the three strata of the ventral muscle; and the intermuscular septa traversing it are, in many places, solidified by conversion into cartilage and bone. Thus, the ribs and sternum, the limb-girdles and the hyoid are developed in it, and chiefly in its inner layers, though they may, and occasionally do, the limb-girdles more particularly, grow through the other strata and come into contact with the *fascia transversalis*, on the one side, and with the skin, or the *fascia superficialis*, on the other.

In the abdomen this stratum forms the *internal oblique*, the *quadratus lumborum*[2], the *rectus*[3] and the *pyramidalis*[4]. The

[1] In Fishes these diaphragms are chiefly formed, so far as they are represented at all, by the fascia alone. The sheet passing upon the bowel near the anus represented in Lepidosiren (Fig. 23) is the only representative of the pelvic diaphragm.

The post-cardiac diaphragm is wanting in Saurians as well as Ophidians (Stannius, 105). In some birds, as Apteryx, it is well developed in its crural, or vertebral, and costal parts, but is deficient in front, where the heart projects through it.

[2] This muscle is carefully described by Carus, Beiträge zur vergleichend. Muskellehre, *Zeitschrift für Zoologie*, III. He regards it as part of the ventrolateral system; he says it is absent in Birds, but present in Chelonians, Ophi-

complete segmentation of the *quadr. l.* from the stratum, above, and of the *rectus* and *pyramidalis*, beneath, is due to the sudden alteration in the direction of their fibres from that of the fibres of the *internal oblique*. The relations of this muscle to both are nearly the same, a layer of it being continued upon the superficial, and another layer upon the deep surface of each; and these layers, forming sheaths for the *rectus* and *quadr. l.*, are in contact, and more or less blended, with the superficial (external oblique) and deep (transversalis) strata of the ventral muscle.

In the thorax the middle stratum forms the series of *external intercostals*. The direction of the slant of the intercostal muscles might indicate the external layer to belong rather to the superficial, or external oblique stratum and the internal intercostals to belong to this middle stratum. But, as we have already found, the fibres in different parts of the same stratum are disposed in very variable directions; and the relations to the intercostal nerves and blood-vessels are stronger grounds for classing the external intercostals with the internal oblique and

dians, Saurians and Batrachians; that in Man it sometimes passes to the body of the 11th dorsal vert. and to the 11th rib, in the Buffalo to the 4th hinder dorsal vert. and ribs. In some animals, as Hyrax (see Meckel), it advances still further forwards. In Cryptobranch its representative is not segmented from the rest of the ventral muscle, but, like that of the rectus, is continuous with it. In Pseudopus Pallasii it is distinctly a serial correspondent and extension of the intercostals passing from the hindmost rib to the iliac bone (p. 289).

[3] The relations of the *rectus* to the several strata of the ventral muscle vary a good deal. Primitively, as in Lepidosiren and most Fishes, it is continuous, and on a level, with the whole thickness of the ventral muscle. In Cryptobranch it is so with the middle and external strata only, while the internal stratum passes above it. In Snakes a deep part of it seems to be represented by thickening of the intercostal fibres near the extremities of the ribs. Some of these thickened bundles pass from rib to rib, and some from one rib to another at a greater distance. And in them, and more clearly in Pseudopus P. (p. 288), it, or the chief part of it, lies on a plane superficial even to the external stratum the fibres of which pass into its deeper surface. In Mammals it is completely segmented from all the strata, and lies in the greater part of its course between the layers of the middle stratum.

Müller, *Abhandl. der Berlin. Akad.* 1834, p. 345, and Tab. I, describes and represents the *rectus* as distinct from, and covered superficially by, the *obliqui* in Bdellostoma. This is, however, unusual in Fishes.

[4] The *pyramidalis* appears to have special relations to the marsupial bone, and to the spine and crest of the pubes, which are the representatives of that bone; and its presence as an independent muscle is probably to be associated with the tendency to the presence of this as an independent bone (footnote on p. 16). Functionally, it seems to assist in strengthening the suprapubic region of the abdominal wall; and it is well developed in animals (female Pteropus, *Journal Anat.* III. 301, and Pseudopus P., on page 289) in which, in consequence of an interval between the pubic bones, the *recti* muscles diverge and leave this part of the abdomen comparatively unsupported.

the internal intercostals with the transversalis stratum.—The *levatores costarum* which, like the external intercostals, are overlapped by the dorsal muscle, may also be ranged as members of the middle ventral stratum[1].

The *rectus* is usually continued forwards on the external surface of the sternum and costal cartilages, not unfrequently as far as the first costal cartilage, constituting a *rectus thoracis*. Other longitudinal muscles are sometimes (Aï, Cyclothurus, Otter, &c.) developed, lying also beneath (superficial to) the ribs, more laterally than the rectus, and constituting what may be designated *recti thoracis laterales*[2], to distinguish them from, and mark their relation to, the *rectus thoracis*. These muscles approach or alternate with extensions of the *scaleni* backwards. The *rectus* may (Cyclothurus and Otter) be crossed superficially by a *sterno-costal* muscle passing from the sternum, obliquely forwards and outwards, to the ribs and approaching the *scaleni*. All these belong to the middle or internal stratum of the ventral muscle and are merely illustrations of varying cleavage and segmentation in accordance with varying direction of fibres.

From the ribs the middle stratum is continued forwards laterally to the cervical transverse processes as *scaleni*. These are separated from the *rectus capitis* and *longus colli* of the internal stratum (p. 309) by the cervical nerves. As just hinted, they often extend upon the exterior of the ribs, meeting the *recti th. laterales* and the *sterno-costales*[3]. Anterior to the scaleni is the *rectus capitis lateralis*. Nearer the mesial line, inferiorly, the middle stratum is continued forwards to the hyoid[4], thyroid,

1 In Snakes, these last are much developed and extend over a greater range than in other animals, for the purpose of assisting in progression; and there is commonly to be found a series of internal *levatores costarum*, situated external to the outer part of the *depressores*, crossing those muscles and appearing in the interval between them and the *transversalis*. Their position would indicate them to belong to the internal stratum; but the nerves which lie external to the depressors and the transversalis, pass internal to the levators. It may be added that the nerves in these animals do not confine themselves to the intercostal spaces opposite which they escape from the vertebral canal, but, in some instances, cross over one or more ribs, passing between the ribs and the transversalis.

2 One of these has been so named by Macalister, in his description of Aï, *Annals and Mag. of Nat. Hist.*, June 1869.

3 In the Green Monkey the *scalenus* is continued into the *rectus*.

4 The inscriptions in the ventral muscle running forward to the hyoid,

tongue, jaw and pharynx as *sterno-hyoid* and *sterno-thyroid*, as *hyo-glossus* and *genio-hyo-glossus*, and as *hyo-* and *thyro-pharyngeus*, or middle and inferior *constrictors* of the pharynx. These come into relation with muscles ascending to, or descending from, the skull, which probably also belong to the same stratum, viz. *stylo-glossus*, *stylo-hyoideus* with the hinder portion of the *digastricus*[1], *stylo-pharyngeus*, superior *constrictor* of the pharynx, as well as the faucial and palatal muscles.

From the outer surface of the middle stratum muscles are detached to the shoulder-girdle. Those passing to the part of the girdle above the glenoid cavity (the scapular part) constitute the *costo-scapular* or *serratus* group. They consist of one or more muscles attached to the ribs, interdigitating and sometimes connected by continuity of fibres with the external oblique, so as to present strong claims to be regarded as part of the same stratum with it; but in their course they are deep; and they are inserted into the deeper surface of the margin of the scapula, on one or two sides, between the *sub-scapularis* and the other muscles which are inserted into, or near, the margin of the scapula. Anteriorly, this group is prolonged into the neck as the *levator scapulæ* which is not unfrequently continuous with the *serratus*, and as the *omohyoid*[2]. The muscular

present in Lepidosiren and others, are not unfrequently represented by one inscription near the middle of the sterno-hyoid. This inscription is continued into the omohyoid with which the sterno-hyoid is sometimes continuous; and it is usually persistent in the latter muscle, in Man, where it makes a bend towards the clavicle. Stannius speaks of an extension of the *rectus* to the tongue in Triton.

[1] In the Porpoise this part of the digastric only is present passing from the hinder part of the temporal to the hyoid. It is called occipito-hyoid by Rapp, *Die Cetaceen Zoologisch-anatomisch dargestellt*, s. 132, and by Stannius, *Müller's Archiv*. 1849, s. 7, but is regarded by Stannius as the posterior belly of the digastric. For account of the anterior part see page 324.

[2] The *omohyoid* may be, as in Phoca, continuous with the *sterno-hyoid*, forming a broad muscle inserted into the sternum, the ulnar tubercle of the humerus and a fascial band between the two. It may, as in Scinc, be attached to the clavicle as well as to the scapula; and the *sterno-hyoid* is in that animal attached to the interclavicle, or episternum. Tendinous traces of the clavicular attachment bend it towards the clavicle in Man, and are, partly or entirely, the cause of the persistence of the inscription or interruption in its muscular fibres. Though in the same plane with the *levator scapulæ*, it is separated from it by the situation of the branchial opening, which also separates the members of the superficial brachio-cephalic stratum (the sterno-mastoid and trapezius) that overlie this region. In the Hippopotamus it passes from the side of the basi-hyal and the sub-hyoidean septum to the under surface of the occipito-humeral part of the trapezius which it joins at an angle, and is united to it by an inscription. The foremost fibres run on without any definite inscription to

derivations from this layer, which pass to the girdle beneath the glenoid cavity, are the *sterno-* or *costo-coracoids.* When the coracoid is abortive, the *costo-clavicular,* called *subclavius,* may take the place of the *costo-coracoid*[1]; and when both coracoid and clavicle are abortive, the member or members of the group may pass to the under surface of the scapula, constituting the *costo-* or *sterno-scapulars*[2]. Thus, spreading beyond their usual limits, these may come into close relation with the serratus group. Or the serratus, extending lower down than usual, may come into close relation with the costo-coracoids. Still the two groups—the costo-scapular and the costo-coracoid or costo-clavicular—are, I believe, always separated by the nerves to the limb passing between them.

These two groups of muscles passing, respectively, to the scapular and to the coracoid or the clavicular parts of the shoulder-girdle, together with the muscles passing forwards to the hyoid, tongue and jaw, constitute that which I have designated (pp. 262, 285) the DEEP BRACHIO-CEPHALIC STRATUM of the VENTRAL MUSCLE. In animals (Snakes and Urodelans), in which the inferior wall of the thorax is not closed in by the sternum and the costal cartilages, the middle, or cephalic, part of the stratum may be continued onwards, uninterruptedly, to the hyoid and the mandible, but it is not segmented from the superficial stratum (Fig. 44 and description); or (Fishes, Figs. 26 and 38) it may be interrupted by the coracoids extending athwart the middle line and uniting with one another, and may then be segmented from the superficial stratum.

Traced backwards from the abdomen, the middle stratum

the humerus. In the Pig it passes over the anterior edge of the scapula to the upper edge, and is connected by fibrous tissue with the radial tubercle of the humerus and the deltoid muscles.

[1] These two do not coexist, when the coracoid is large, the muscle passes from the sternum or rib to it, and forms a *sterno-* or *costo-coracoid.* When the coracoid is short the muscle, if present, passes from the rib, or the first or (Orycteropus) second costal cartilage and perhaps the sternum, to the clavicle constituting the *subclavius.* It may, as it does in Orycteropus and Scinc, extend on to the scapula. In the Porpoise the *subclavius* passes from the first rib, near the sternum, to the coracoid; and the *pect. minor* passes from the second rib to the humerus. Stannius, "Beschriebung der Muskeln des Tümmlers." *Müller's Archiv,* 1849, s. 14 and 16, calls the former of these *pect. minor,* and the latter *costo-humeralis.*

[2] The sterno-scapular may coexist with the subclavius. Thus Macalister found the subclavius quite separate from the sterno-scapular and inserted into the clavicle. In such case the muscle is divided into two.

of the ventral muscle encounters the pelvis and is interrupted by it[1]. Its continuations backwards from the pelvis constitute the *ilio-* and *ischio-caudales*[2], the deep *sphincter-ani*, the *erector-penis*, *compressor-urethræ* and *transversus-perinei*, besides the extensions upon the hind limb around the hip-joint to be subsequently mentioned.

I pass now to the disposition of the EXTERNAL STRATUM of the VENTRAL MUSCLE which has the external oblique muscle of the abdomen as its most steady representative, and which I, therefore, sometimes call the EXTERNAL OBLIQUE STRATUM. As already stated, it is the stratum in which the ossifications, not preceded by cartilage, most frequently occur. The 'membrane bones' thus formed are commonly in the situation of the septa, and, therefore, overlie the 'cartilage bones' formed in the septa of the middle stratum. Sometimes they are blended with them, the two being ossified together, or the one may serve as a substitute for the other. Thus the epicostals[3], the episternum[4] and the epicoracoid, or clavicle,

[1] It must not be forgotten, that the rudimentary pelvic bones of Ophidians lie, or rather project upwards, internal to the *transversalis*. Perhaps they originate in the internal oblique stratum, and grow through the transversalis, just as in many animals the ilium presents through the external oblique stratum, and as in the Dog-fish, the scapula pushes its way into the dorsal muscle (Fig. 28). In Pseudopus P., the ilium, though deep, is not quite so deep as in Snakes, a considerable part of the ventral muscle is inserted into, or interrupted, by it, and a distinct strip of the muscle passes beneath it (p. 289).

[2] The ischio-caudal, and the ilio-caudal are, to some extent, serially homologous, respectively, with the costo-coracoid, and the costo-scapular (*serratus m.*); and the nerves to the hind limb pass between them, as do the nerves to the fore limb between the last-named muscles.

The shoulder-girdle, like the pelvic girdle, varies in the depth at which it is placed, and also remarkably in the size of its coracoidal part, and in its connection with the rest of the skeleton above and below. In Fishes the coracoid part is imbedded in the deep stratum of the ventral muscle; but in Cryptobranch, the coracoid, notwithstanding its size, has little direct connection with the ventral muscle, the deep layers of which pass clear of it and above it. In Birds and Reptiles its connection with the deep ventral stratum is re-established by the costo-coracoid muscles. In Mammals the connection is chiefly, through the medium of the *pectoralis minor*, with a deep layer of the pectoral or superficial stratum of the ventral muscle.

[3] In Hatteria the epicostals are more numerous than the costals, occupying not only the lines over them, but the interspaces between those lines: see Günther, *Phil. Trans.* 1867, p. 608, whose description I have in most points verified.

[4] I much prefer the old term, 'episternum' to that of 'interclavicle', proposed by Mr Parker; because it expresses not only its position, but its nature as a bone formed in the membranous tissue upon the sternum, at the same time that it refers it to the same series as the epicostals and the clavicle.—It will be perceived that, for the same reason, I use the term 'epicoracoid' to designate, not the cartilage or cartilages lying between the coracoid and the sternum, but the

are formed, respectively, over the costals, the sternum and the coracoid, and the lower jaw is formed over Meckel's cartilage. We have seen that this stratum is, in Fishes, closely connected with the skin by the transverse and longitudinal septa passing through the compact intervening external fascia.

A superficial layer of the stratum is often, more or less completely, segmented from the rest, and, retaining its connection with the skin, or with the superficial fascia or both, constitutes cutaneous or subcutaneous muscles to which the names *pannicle, platysma myoides*, &c. are given. They may retain their original connection not only with the rest of the external ventral stratum, but also with the deeper strata, and with the cartilage bones. Thus they, in some instances, are united to the ribs and the sternum, the vertebral spines and the limb-bones. They often correspond, and are more or less blended, with the several divisions of the rest of the stratum, and will therefore be best considered in relation with them. They commonly extend over the lateral septum, spreading upon the dorsal muscle, and reaching the dorsal mesial line. This also we shall find to be the case with the rest of the stratum. Or, which is much the same thing, the components of this external stratum of the ventral part of the lateral muscle are confluent with superficial dorsal fibres, and form one stratum with them; so that it might be called the 'external ventro-dorsal', or, better, the 'external lateral' stratum, that is, the external stratum of the entire lateral muscle[1]. See Diamond Snake (Fig. 44)[2].

membrane bone, or clavicle, formed upon it, and often in close connection with it.

[1] This extension of the external stratum of the ventral part of the lateral muscle, over the lateral line and over the dorsal part of the muscle, to the vertebral spines is due, perhaps, to the expansion of the visceral cavity, laterally and upwards, as seen in the section of the Tadpole (Figs. 42 and 43).

[2] Description of Fig. 44, Pl. xvi.—The DIAMOND SNAKE.

Dissection of the fore part of a Diamond Snake.—The pin is inserted into the fore part of the cerato-hyoid cartilage which is seen running back among the muscles. The drawing shews the bundles of the external oblique arising partly from the lateral septum, and partly from the fascial tissue on the surface of the dorsal muscle and passing, downwards and backwards, into the antero-posteriorly directed fibres of (*r.*) the rectus abdominis. Traced forwards, the rectus is seen giving off the bundles of the external oblique. Anteriorly, it expands into a muscular sheet, in the middle of the thickness of which the hyoid is involved. This runs forwards to the lower jaw, covers the under part and sides of the throat, expands upon the side of the head and neck, and extends over the dorsal muscle to the cervical spines. A set of its bundles more distinct than the others runs to the angle of the mouth, constituting a *retractor oris*.

This expansion is a continuation of the entire thickness of the ventral mus-

In the abdomen the stratum is chiefly represented by the external oblique which extends upon the exterior of the thorax, and the fibres of which often blend with the fibrous tissue over the dorsal muscle. Anteriorly, it is continued, or its superficial fibres are continued, with a variable amount of interruption, into a 'superficial brachio-cephalic' sheet which extends to the face and head, which is distorted by encountering the fore limb and its girdle, and the fibres of which converge upon the limb, as though, like the skin, they had been pushed before it as it grew out from its girdle. Hence, opposite the limb, the fibres are directed transversely, from the ventral and dorsal mesial lines, upon the limb; whereas, before and behind, they have a more oblique or antero-posterior direction.

As it advances towards the fore limb the inferior, or ventral, part of the superficial brachio-cephalic sheet resolves itself into the *pectoralis major*, the fibres of which converge upon the radial edge of the humerus, inclining to the plantar aspect; the superior, or dorsal, part of the sheet resolves itself into the *latissimus dorsi*, the fibres of which converge upon the ulnar side of the humerus, and are often, to some extent, blended with the muscles on the dorsal aspect of the limb. I say, to some extent, because the prolongations upon the middle and distal segments of the limb of both the inferior and superior parts of the sheet shew an inclination to the plantar aspect, which is a consequence of the position and flexures of the limb. The two—*pectoralis* and *lat. d.*—may (Lepidosiren, p. 259) be united and pass as a continuous sheet upon the radial and ulnar margins and upon the intermediate, plantar or axillary, that is, the posterior aspect, of the shoulder and limb. More commonly they are separated by the axillary interval; or, connecting axil-

cle, and contains therefore the elements of all the muscles covering the under part and sides of the neck, and passing between the thorax, hyoid and jaw. It represents, in short, the whole of the brachio-cephalic stratum of Lepidosiren and Dog-fish,—the cervicalis profundus, that is, as well as the cervicalis superficialis;—and it includes therefore the factors of the sterno-mastoid and trapezius, the platysma, constrictor faucium, &c. A continuation of it backwards would represent the pectorals and latissimus dorsi as well as the serratus.

Though its hinder edge seems to be marked off from the oblique, yet its connection, and the connection of the oblique with the rectus, and the fact that the oblique bundles cease where this more continuous expansion begins, shew that it is a serial continuation of them, of the parts of them more especially which extend upon the dorsal muscles.

lary bands, may remain as a result of imperfect segmentation[1]. The term 'achselbogen' has been applied to them. The term 'axillary' is that by which I will designate them.

The *costo-alaris* (*costo-anconeus*) of the Bird is an interesting example of one of these 'axillary' muscles, being segmented from both the *pectoral* and the *latissimus dorsi*, and passing from the ribs, between the two, near to the *serratus*, along the inner side of the arm, to or near the inner condyle of the humerus. In the Swan I found part of it elastic, where it occupied the hinder fold of the axilla, and traced it along the ulnar margin of the wing, and in the retiring angle beneath the carpus, to the skin and tissue binding the skin to the ulnar phalanges. Thus it presents interesting antagonistic homological affinities to the *tensor plicæ alaris;* and by its near relation to the *serratus* on the deeper side, and by its blending with the cutaneous muscles and the skin on the superficial side, it is an interesting relic of the primitive union of the several strata.

The relation of this brachial, or hinder part, of the superficial brachio-cephalic sheet to the rest of the external oblique stratum varies a good deal. In many animals, for instance, the *pectoral* is a continuation of the whole thickness of the *external oblique*, or of the whole or great part of the *rectus*. In Cryptobranch it is almost entirely derived from these. In others, it is a superficial stratum only of the oblique, extending perhaps to the pubes. In others again it arises from the outer surface of the aponeurosis of the oblique; and in Hatteria it appears to arise from between its layers[2]. In Man it is usually continuous with the oblique by means of only a few muscular fibres. In the Hippopotamus it is largely continuous with the subcutaneous muscle over the oblique; whereas in Birds its origin is so confined to the sternum and the clavicle that we should little have thought of regarding it as an extension of the abdominal stratum, had our attention been limited to its anatomy in them. In like manner the *latissimus dorsi* is, in some, confined to the neural spines, in others extends upon the ilium; and, not unfrequently, it derives origin from the hinder ribs, where it may (Seal) meet, and be united with, the pectoral. In the Porpoise its origin is confined to the 5th, 6th and 7th ribs[3].

[1] A good illustration of these axillary muscles was presented this winter by a female subject in the dissecting-room of this University. A slip from the lower edge of the *pectoralis*, and another from the anterior edge of the *latissimus dorsi* in each arm, ran through the axillary space and, meeting, were inserted together into the fascia covering the *coraco-brachialis*.

These connecting bands are commonly large in Carnivora. They are usually formed by an extension of the *latissimus dorsi*, or parts of it, beneath the axilla, to the pectoral muscle and the pectoral ridge of the humerus; while another part of the *lat. d.* runs along the inner side of the triceps to the inner condyle forming the *dorsi-epitrochlien.*

[2] *Phil. Trans.* 1867, p. 609. In Pteropus, *Journ. Anat.* III. 300, it is in three separate parts, an abdominal, a sternal, and a clavicular.

[3] The variation in the mode in which cleavage of strata may take place is illustrated by the fact, that in Birds and Reptiles the *lat. d.* usually overlaps the

All this hinder, post-brachial, portion of the external stratum of the lateral muscle may be covered by a superficial, or subcutaneous, layer, which varies much in thickness, and which may be connected with one or all of the divisions of the stratum, sometimes reciprocating with them in size and thickness, as in the Hippopotamus. Like them it converges upon the arm; and, accompanying the pectoral more particularly, it may be lost in that muscle, or it may be inserted into the humerus or the coracoid.

It is often a muscle of such size, and of so powerful action upon the arm, and radiates from the arm so widely upon the flank, that I have[1] described and named it as *brachio-lateral*. Sometimes it, or part of it, lies upon and is closely united with the *latissimus dorsi*; or it may be (Hatteria) continuous with its lower edge. Sometimes (Manis) it is difficult to separate from the skin on the one side and the external oblique on the other[2]. As mentioned above, it forms part of the *costo-alaris* of the Bird.

Traced forwards into the pre-brachial or cervical region the SUPERFICIAL BRACHIO-CEPHALIC STRATUM, which we are considering, is, after a certain interruption caused, partly, by the shoulder-girdle, and, partly, by segmentation from alteration of the direction of its fibres, continued as a superficial cervical sheet —*cervicalis superficialis*. It covers the neck, from the shoulder-girdle to the skull, and from the ventral median line to the

trapezius, the reverse being the case in Mammals. In the Rabbit the two muscles are continuous.

[1] *Journ. Anat.* IV. 27.

[2] The superficial, cutaneous layer is well developed in the Porpoise, where it spreads upon the fins, under the abdomen, and under the sheath of the penis; and in the female it passes beneath the mammary gland, detaching fibres which encircle the lower dilated part of the duct, so as to compress it during suckling. It attains its maximum in the Hedgehog, being connected with the frontal and occipital bones, the lower jaw, sternum and humerus, and the dorsal and caudal spines, and forms a thick sphincter around the body beneath the line where the bristles terminate.

In the Guinea Pig both *pectoral* and *trapezius* are continuous with the pannicle. In the Pig, and many Animals, the brachio-lateral part extends over the thigh. In the Hippopotamus it is very largely developed, forming a thick mass over the abdominal muscles, which are almost dwarfed or supplanted by it, though quite distinct from it; it extends over the thigh and the knee; and it is also continued into the pectoral.

In Snakes the continuity of strata is manifested and maintained by the bundles of the oblique abdominal muscles passing from the ribs directly into the ventral scutes, which are thus enabled to act as organs of locomotion. Some of the bundles running horizontally for a distance, from scute to scute, constitute (pp. 313, 327) a superficial or subcutaneous *rectus*.

lateral line; and it commonly extends, in a muscular form, beyond the lateral line, to the dorsal median line. Anteriorly, it is connected with the whole circumference of the skull, and sends superficial prolongations over it. It is well exhibited in Lepidosiren (Figs. 24 and 26), Dog-fish (Figs. 28 and 29), and Ceratodus (Figs. 34 and 37), and I have named the ventral part of it, lying beneath the level of the gills, *cervicalis superficialis inferior* (*C. s. i.*), and the dorsal part of it, lying above the level of the gills, *cervicalis superficialis superior* (*C. s. s.*). These two parts are, however, continuous upon and above the gill-cover; and the superior or dorsal portion (*C. s. s.*) seems rather to be an extension from the inferior or ventral portion (*C. s. i.*), just as the ventral and dorsal portions of the postbrachial part of the same stratum are often continuous, and the latter seems to be an extension from the former.

In animals like those just mentioned, where there are gills with the attendant opercular structures, the *cervicalis superficialis* is but a thin expansion, and does not present any distinct segmentation beyond that—often not very distinct, into *levatores, depressores,* &c. *arcuum*—which is requisite for the movements of the branchial apparatus. Where, however, the gills are abortive it acquires increased thickness and is stratified and segmented.

A superficial layer forms the *subcutaneus colli* or *platysma* which covers the neck and is prolonged forwards upon the face and head, where it blends with and is continued into the facial muscles, the auricular muscles and the *occipito-frontalis.* It is prolonged backwards upon the thorax and fore limb to an indefinite extent, blending with the *brachio-lateral* and, like it, finding its way to the osseous structures of the limb. As in the case of the *brachio-lateral,* portions of it may blend with, or supplant, segments of the subjacent layer.

In some instances it is continuous with the *trapezius;* and in Pteropus it takes the place of the cervical portion of that muscle[1]. A remarkable detachment from between its dorsal and its ventral

[1] Macalister finds that the muscle, which thus in Bats supplants the cervical part of the *trapezius,* is supplied not by the spinal accessory, but by cervical nerves and the seventh nerve.

portions, blended with a similar detachment from the deeper layer (from the contiguous edges of the pectoral and *trapezio-deltoid*), forms the *tensor plicæ alaris*, better called *cervico-alaris*. This, partly composed of elastic tissue, extends along the radial edge of the wing in Bats and Birds, and reaches the skin and subcutaneous tissue of the radial digits. It is thus (as mentioned p. 319) the antagonistic homologue of the *costo-alaris*.

The deeper layer of the *cervicalis superficialis* developes into the *sterno-cleido-mastoid* and the *trapezius*, the former representing the ventral, or sub-branchial, part of the layer, and the latter representing the dorsal, or supra-branchial part[1]. They are very regular muscles, but vary in their range of attachment at both ends. The *sterno-cleido-mastoid* is sometimes confined to the sternum and then is called sterno-mastoid. Sometimes it is inserted, by a narrow tendon only, into the mastoid, instead of by a broad musculo-tendinous termination as in Man[2]. Sometimes the portion connected with the clavicle is separate, forming a cleido-occipital. The *trapezius*, instead of the extensive origin from skull, cervical and dorsal spines, overlapping the *latissimus dorsi*, which it has in Man, may (Pteropus and Birds) have much more limited origin. It may, in the absence of the clavicle, be inserted (Cryptobranch) into the anterior edge of the scapula and the precoracoid or (Aï) the coracoid; or it may be continued as trapezio-deltoid to the humerus[3]. When this last occurs, there is usually an inscription remaining between the *trapezius* and the *deltoid*, in the deeper part of which a rudimentary clavicle is often present in Carnivora.

From beneath the *trapezius* the *rhomboids*[4] are segmented,

[1] The interval between the two in Racoon is partly bridged over by fibres passing from the trapezius to the sterno-mastoid, reminding us of the epi-branchial fibres connecting the *superior* and *inferior cervicales* parts in Lepidosiren and Dog-fish.

[2] In a Fawn I found it extending over the lower jaw to the orbital edge of the maxilla, occupying that part of the area of the superficial layer. In Crocodile it passes beneath the *trapezius* to the transverse process of the 4th cervical vertebra, where it comes into contact with the middle ventral stratum represented by the *levator scapulæ*.

[3] In Manis it extends over the *biceps* and brachial vessels to the internal condyle of the humerus.

[4] The *rhomboid* in Owl and Kite extends from all the lumbar and dorsal spines to the hinder edge of the scapula, dwarfing the *trapezius*. In Apteryx it is said by Owen to be wanting. It is present in the Crocodile, but I have not met with it in any lower animal; sometimes it blends with the *latissimus dorsi*. *Journ. Anat.* IV. 33.

also apparently the *serrati postici*, as well as the *masto-humeral* and *masto-scapular*. Though the last two might perhaps be said to be segmented from the deep surface of the sterno-mastoid, yet they usually blend below with the trapezius or deltoid, or pass to the scapula or humerus. Also another muscle is segmented from the trapezius, which I have in former papers named *cervico-humeral*, and which is an interesting reminder of the fact that in Lepidosiren (p. 260) and Dog-fish (p. 274) some of the deeper fibres of the layer are traceable to the lateral septum and, beneath it, to the lateral parts of the vertebræ; for the *cervico-humeral* arises, not like the *trapezius* from the vertebral spines, but from the transverse processes of the atlas or other cervical vertebræ, near to the *levator scapulæ*, or even (Hedgehog) from the fore part of the ring of the atlas, or (Guinea Pig and Rabbit) from the basi-occipital. It descends upon the shoulder to the clavicle, acromion, or humerus, or blends with the trapezius or deltoid. Thus, though it is associated with the *levator scapulæ* in its origin, it is associated with the *trapezius* in the latter part of its course; and it is evidently a representative, in Mammals, of those fibres of the stratum which, in Lepidosiren, detach themselves from the rest of the stratum and bend in, deeply, to the sides of the vertebræ. In the Hippopotamus the *cervico-humeral* arises by a round tendon from the back of the exoccipital, behind the digastric and stylo-hyoid, joins the *trapezius*, forming its fore part, and runs on to the deltoid ridge of the humerus. It is not separated from the deltoidal, or lower, part by any inscription. It is joined by the omo-hyoid which loses itself in this muscle. It is called masto-humeral by Gratiolet. A separate large portion arises by a strong tendon from the under surface of the transverse process of the atlas and spreads upon the dorsum of the scapula. The *trapezius* passes over the large transverse process of this vertebra without deriving any fibres from it.

Between the two layers of the cervical part of the superficial brachio-cephalic stratum, just described—the *superficial* layer which is forming the *subcutaneus colli*, and the deeper layer which forms the *sterno-mastoid* and *trapezius*—other muscles are developed in different animals, to which the names *cervici submaxillaris, depressor mandibulæ, mylo-hyoideus* and *genio-hyoideus* are given. These vary a good deal; and the first two are absent in higher animals. I have said that they are found between the two layers; but the genio-hyoid, which lies near the middle line, is perhaps rather to be regarded as segmented from the deeper surface of the superficial layer. The most remarkable member of this series is the anterior belly of the digastric. It lies in a more superficial plane than any, yet is continued, through the medium of a tendon or inscription, into the posterior belly which runs, in company with the stylo-hyoid, beneath the sterno-mastoid, to a deeply situated spot of the temporal bone, just behind the styloid process.—The peculiar conformation and disposition of this muscle in Man, and the inscription which in many lower animals is substituted for the tendon between its two muscular portions, have excited much attention and been the cause of many surmises. I believe the real explanation of it to be that it is composed of two muscles or muscular portions derived from the two strata of the brachio-cephalic muscle. The hinder portion is, together with the stylo-hyoid, a derivative from the deep stratum, which it will be remembered is an extension of the middle or internal oblique stratum of the ventral muscle; and the anterior portion is a derivative from the fibres of the *cervicalis superficialis* layer, which lies next above the *subcutaneus colli*. It is an instance of a portion of a deep stratum retaining continuity through the medium of a septum with a portion of a superficial stratum. The septal remnant, which is a remnant of the hyoidean, or sub-hyoidean, septum (the septum, that is, in which the hyoid is formed), is the tendon of connection between the two portions and the band which holds them to the hyoid[1].

[1] It may be observed, as affording some confirmation of the relation described in the text between the anterior belly of the digastric and the mylo-hyoid, that they are both supplied by the mylo-hyoid branch of the 5th nerve; whereas the posterior belly of the digastric and the stylo-hyoid are both supplied by the 7th nerve. I do not however attach much importance to this.

In this derivation of the digastric from the elements of deep and superficial strata, we are reminded of the same thing in the *cervico-humeral* just mentioned, and in the *costo-alaris* (p. 319).

The dissection of the Hippopotamus[1] (Figs. 45 and 46) affords an interesting illustration and confirmation of these views. The *subcutaneus colli* (*S. c.*) under the neck is of great thickness, as is the case with the subcutaneous muscles on the under surface of the body generally; and it appears at first sight to terminate in front in a thick defined border extending, on either side, upon the middle of the large mandibular protuberance into which the masseter (*M*) is inserted. The muscle at and near this border is further thickened by transverse fibres crossing from one side of the face, over the mandibular protuberance, to the other side. Close examination, however, shews that the anterior border is not so defined as at first sight appears; for the edge is connected by fibrous tissue, which is the sub-hyoidean septum[2], with deeper-lying muscle, a broad, thick *hyo-mental* (*A. M.*), which passes forwards, from the septum just mentioned, to the mandible on the side of the bulging symphysis. By means of this septum the *hyo-mental* is continuous, behind, with the superficial fibres of the *sterno-hyoid* (*St. H.*) which is a large thick muscle, on its deeper surface, with the basi-hyoid bone, and, on its superficial surface, with the edge of the *subcutaneus colli*[3]. Above it, and deeper than it, is the *mylo-hyoid* (*M. H.*) Above this is (*G. H.*) the *genio-hyoid*, and deeper still is the *genio-hyo-glossus*. These are disposed as they usually are in Mammals. The *stylo-hyoid* arises, tendinous, from the outer side of the tooth-like exoccipital process, soon expands into a muscular belly which is, partly, inserted into the hyoid, on a

[1] Description of Figures of the HIPPOPOTAMUS and the CAT (Pl. XVI.).

Figs. 45 and 46. Dissections of the muscles beneath the floor of the mouth of a Hippopotamus which died three days after birth.—*I. M.*, the inferior maxilla, with its large submental protuberance uncovered.—*L*, the upper lip.—*S. c.*, subcutaneus colli.—*M*, Masseter.—*H. M.*, hyo-mental entire on the left side, but divided on the right side, and, in Fig. 46, reflected.—*D.*, anterior part of digastric running parallel with, and blended near the jaw with, the hyo-mental.—*M. H.*, mylo-hyoid divided and partially removed to expose *G. H.*, the genio-hyoid.—*F. A.*, the facial artery.—In Fig. 46, the subcutaneus colli has been removed, exposing the hinder part (*D'*) of the digastric, also *S. H.*, the stylo-hyoid which is seen to be continuous with the hyo-mental.—*St. M.*, sterno-mastoid.

Fig. 47.—Similar dissection in Cat. *S. c.*, the subcutaneus colli, or platysma, has been divided and pulled aside to shew (*D* and *D'*) the anterior and posterior parts of the digastric, with the inscription between them which is the sub-hyoidean septum. The anterior part of the digastric is seen to occupy the position occupied by the hyo-mental, as well as by the anterior part of the digastric, in the Hippopotamus.—*M. H.*, the mylo-hyoid.—*St. H.*, sterno-hyoid.

[2] It is called by Gratiolet, *Recherches sur l'Anatomie de l'Hippopotame*, p. 246, the *raphé-sous-hyoïdien.*

In the Flying Squirrel Macalister found that the digastric had two separate bellies and a central round tendon which was continued across, from side to side above the hyoid bone, as an arch from which the anterior bellies arose. This tendinous arch was the sub-hyoidean septum. I have met with a similar arrangement in the body of a man, in the University dissecting-room, this winter.

[3] Gratiolet (p. 299) describes it as *le second faisceau* of the digastric. It is in the plane of the digastric; its mandibular insertion is blended with the insertion of the digastric, and it occupies the place of the anterior belly of that muscle in Man. A *hyo-mental* is present in some Bats, according to Macalister.

level with the mylo-hyoid and the genio-hyoid and, partly, is continued on into the lateral edge of the hyo-mental. The *digastric* (*D'*) arises, by a tendon, from near the extremity of the same process as the stylo-hyoid, passes internal to the stylo-hyoid, expands into a belly which, about on a level with the hyoid, is interrupted by a transverse inscription[1]. In front of this (*D*) it runs parallel, and on the same level, with the hyo-mental and is inserted, behind the hyo-mental, and continuously with it, into the lower edge of the body of the jaw, midway between the symphysis and the angle.

The facial artery (*F. A.*) passes, as usual, beneath the stylo-hyoid and digastric, and runs along the outer and posterior side of the digastric, over the side of the jaw, between the digastric and the fibres of the masseter which are curling round the anterior border of the protuberance to be inserted into its inner side and edge.

The points shewn by this dissection are, first, the connection of the *subcutaneus colli* with, and its termination at, the hyoidean septum. Secondly, the presence of a hyo-mental muscle superficial to the mylo-hyoid, extending from the hyoidean septum to the symphysis of the jaw, and the continuity of some of the fibres of the *stylo-glossus* with it. Thirdly, the position of the anterior belly of the *digastric* (*D*), in front of the inscription, on a level with, and on the side of, a part of the same stratum with the hyo-mental, and, indeed, continuous with that muscle, and forming a lateral portion of it. It is clear that the inscription in the digastric is a part of the sub-hyoidean septum, and that the hinder, deeper, belly (*D'*) of the digastric is, by the medium of this inscription, continued into the lateral part of the hyo-mental, which forms the anterior belly; just as some of the fibres of the stylo-hyoid are continued into the middle part of the same muscle. In Man the lateral portion of this hyo-mental is absent; and it is the median portion which forms the anterior belly of the digastric. Hence the insertion of the digastric is near the symphysis of the jaw. The shifting insertion of the digastric into the jaw is thus explained by the circumstance that its anterior belly may be formed by different parts of the hyo-mental in different animals; and the inscription, usually observable, even when the muscle is straight, indicates the line of connection of the portion of the deep, or masto-hyoid, and the superficial, or hyo-mental strata which combine to make up the muscle. The hyo-mental portion, anterior to the inscription, or remnant of the sub-hyoidean septum, is a part of the superficial brachio-cephalic stratum; and the masto-hyoid portion, behind the inscription, is a derivative from the deep brachio-cephalic stratum.

[1] Gratiolet, whose account corresponds in other respects with that in the text, observes that the muscular fibres are not interrupted by any tendinous inscription. It is, however, quite distinct in the young (3 days old) animal from which my description is taken.

In the Cat (Fig. 47), as in many others, the *digastric* is a straight muscle, slightly constricted and crossed by a distinct inscription where it passes the hyoid, with which it is unconnected. Then it expands to be inserted into the whole of the inner surface of the body of the mandible between the symphysis and the masseter. There is no *hyo-mental*.

It is worth while to remark that the hyo-mental in the Hippopotamus is, together with the anterior belly of the digastric, supplied by the mylo-hyoid branch of the fifth nerve which runs between them and the mylo-hyoid muscle.

In the limbless Saurians (Pseudopus, P.) the *rectus abdominis*, which forms the median part of the superficial stratum of the ventral muscle in the abdomen, is not separated from the cervical (*sterno-mastoid*) part by an intermediate, thoracic, transversely disposed (*pectoralis*) part, but is continued directly on into it, or with only some interruption of the deeper fibres by the clavicle. In Snakes the foremost bundles of the external oblique muscle arise from the mastoid process, and run backwards towards the ventral scutes beneath which they form a superficial *rectus*. Thus they represent the sterno-mastoid muscle in the same manner as do the corresponding fibres in Pseudopus P. For a short distance near the head the *obliquus* is overlaid by a superficial, thin muscular sheet extending from the cervical spines to the mandible and the scutes immediately behind it. This is described as being divided into *cervici submaxillaris* and *depressor mandibulæ*; and it corresponds evidently with part of the *cervicalis superficialis* of Lepidosiren and Dog-fish. But it is not interrupted by branchial openings; and it is not segmented from the subjacent layers of the ventral muscle, at least it does not present a stratification from them; although such separation may be indicated by the presence of the hyoid in the thickness of the sheet (see Fig. 44 and description[1]).

Traced backwards the superficial (external oblique) stratum of the ventral muscle is continued upon the hind limb, with more or less interruption by the limb-girdle ; and it ensheaths the femoral segment much in the same manner as the humeral segment of the fore limb is ensheathed by a projection of the anterior prolongation of the stratum[2]. Ventrally, it is continued

[1] Some of the fibres of this—the *cervici submaxillaris*—part of the stratum are described by Prof. E. d'Alton (Beschriebung des Muskelsystems eines Python bivittatus, *Müller's Archiv*, 1834, s. 355) as attaching themselves to the hyoid, forming a 'Nackenzungenbeinmuskel.' He also describes a 'Rückwartszieher' of the hyoid running obliquely and superficially from the cervical spine to the hyoid. Some fibres of the cervici- or masto-submaxillaris attaching themselves to the quadrate, he calls 'Zurückzieher' of that bone. It is an extension of these upon the mandible which forms the *depressor mandibulæ*.

[2] In certain Snakes the ventral muscles form a funnel-shaped process investing the base of the claw, which is the counterpart of the funnel-shaped

into the *gracilis,* which is, manifestly, a serial repetition of the *pectoralis,* and which, like that muscle, is chiefly attached to the pre-axial edge of the limb. Dorsally, it is continued into the *gluteus maximus,* which is the serial repetition of the *latissimus dorsi,* and which, like that muscle, is attached to the post-axial edge of the limb and blends with the dorsal muscle (the *quadriceps*) on the first segment of the limb. Both these muscles (*gracilis* and *gluteus*) incline to the plantar surface of the middle and distal segments of the limb, as do the *pectoralis* and *latissimus dorsi* in the fore limb, and for the same reason. The middle part of the external oblique layer is continued into the *tensor vaginæ femoris* and the *sartorius,* which are the representatives of the *deltoid* muscle, and which are cut off, wholly or in part, from the *obl. ext.* by the ala of the ilium, as the *deltoid* is wholly or in part cut off from the *trapezius* by the spine of the scapula. The opposed edges of the *sartorius* and the *gracilis*[1] are not commonly so approximated to each other as are those of the *deltoid* and *pectoralis.* In the interval between them, as well as upon them, the oblique muscle is continued into the fascia of the thigh; and the thickening called 'Poupart's ligament' at the crural arch, where the oblique passes into the femoral fascia, is probably a remnant of the pelvic septum; and an ossification in it would form the serial homologue of the clavicle[2].

These muscles and fasciæ are sometimes covered by an extension of the brachio-lateral muscle (p. 320), which may (*Pteropus*) acquire an attachment to the femur; just as in

investment carried upon the fore limb of higher animals and segmented into *pectoralis, latissimus dorsi,* and *trapezio-deltoid.* Commonly the interruption of the components of the stratum by the pelvic girdle is greater than that by the shoulder-girdle. Thus the *gracilis* is often quite separated from the rest of the ventral muscle; though in some animals, as Cryptobranch, its continuity with the caudal and abdominal parts of the stratum is sufficiently clear: whereas the *pectoralis* is usually to some extent, and often very extensively, continuous with the external oblique, or the rectus, or both. So, the *sartorius* and *tensor vaginæ femoris* are rarely (they are in Aï) continuous with the external oblique; though the *deltoid* often is continuous with the *trapezius.*

[1] In the Rabbit the *sartorius,* arising from Poupart's ligament, is continuous with the *gracilis.*—In Aï, Manis, Pig, and others, the *sartorius* and *tensor v. f.* are continuous with the *gluteus;* and in Pig the *biceps* also is continuous with them.

[2] Probably the marsupial bone, formed from cartilage in the deeper part of this septum, corresponds with the sternal end of the clavicle, which, its epiphysial nucleus at any rate, is formed in cartilage.

the fore limb the subcutaneous muscle dips down to and is united to the humerus.

Behind the limb the external stratum is continued upon the tail and there blends with the middle stratum. Its superficial or subcutaneous layer forms the external *sphincter ani.* In some animals (Hedgehog) it is firmly inserted into the caudal vertebræ.

The following is a review of the serial or successional homological relations of the parts of the external stratum of the ventral muscle thus far discussed. The *gluteus max.* is serially homologous with the *latissimus dorsi.* The *tensor vag. f.*, the *sartorius*, the *femoral fascia* and part of the *obl. ext.*, with the *deltoid* and *trapezius;* Poupart's ligament representing the clavicle, and the ala of the ilium representing the spine of the scapula. The *gracilis* with the *pectoralis major.* The middle part of the *external oblique* and the superficial fibres of the *rectus* with the *sterno-cleido-mastoid,* and (between the sterno-mastoids) with the *mylo-hyoid*, the anterior belly of the *digastric*, the *hyo-mental* and the superficial fibres of the *sterno-hyoid.* The *rhomboids* and *serrati postici* have no homological representatives; and there are no structures in the tibial and fibular borders of the hind limb sufficiently segmented to compare with the *tensor plicæ alaris* and the *costo-alaris*; though the *sartorius* or some of its fibres nearly corresponds with the former, and the *caudo-pedal* with the latter. The *external sphincter ani* may be said to be serially homologous with the *orbicularis oris;* but the subcutaneous muscles generally do not admit of homological comparison.

The relations of the ventral muscles to the alimentary tube are therefore as follows:—The internal stratum is gathered round, continued into and reflected upon it as *levator* and *retractor ani* and is gathered round it as post- and sometimes as pre-cardiac diaphragm. The middle stratum forms the internal *sphincter ani,* and is continued into the tongue as *genio-hyo-glossus* and *hyo-glossus*, and is continued upon the pharynx as *thyro-* and *hyo-pharyngei* or *constrictores.* The external stratum forms, by its superficial layer, the *orbicularis oris* and other circum-oral muscles, and the *sphincter ani externus.*

The disposition of the ventral muscle in these three, oblique and transverse, planes is a visceral feature, is co-extensive, that is, with the visceral region or nearly so. It extends from the anus to the head, but not behind the anus, even in Bdellostoma, Snakes and other limbless animals. When the limb-girdles are present, either with or without the limbs, the planes are broken up by and partially lost on them; and when they are not present the planes are blended in the caudal muscles. In the Porpoise the *recti,* and with them the *obliqui interni* and the *transversi,* diverge and pass, on the sides of the bones supposed to be rudimentary pelvic bones, to the transverse vertebral processes in which they terminate about on a level with the vent; while the *obl. externi* terminate in a defined edge a little in front of the bones just mentioned. It will be understood that the stratification is no necessary accompaniment of the visceral region. It does not usually take place there in Fishes; and in higher animals it is often obscure or imperfect in certain parts, rendering it difficult or impossible to decide with certainty from which of the strata a given muscle is derived.

Muscles of the Limbs.

It has already been shewn that limb-girdles are, like the ribs and costal cartilages, formed in the transverse intermuscular septa of the ventral muscle, and in that part of the thickness of the septa which is in the plane of the middle or internal oblique stratum. They sometimes grow through the outer stratum and project subcutaneously; and the pelvic bone in Snakes lies, beneath the internal stratum, in juxta-position with the fascia transversalis. Essentially, however, they belong to the middle stratum; and the muscles passing from them upon the limbs may be regarded as derivatives from this stratum, as serially homologous, that is, with the muscles passing from septum to septum, or from costa to costa, in front and behind them.

It has also been shewn that the external stratum—the stratum of the external oblique muscle—is prolonged upon the limbs in the form of a more or less complete funnel-like investment of each limb. This is seen in its simplest condition in the Snakes that are possessed of claws. It is also well seen in Lepidosiren, where it consists of a simple sheath, interrupted, it is true, in front, by the branchial opening, yet surrounded by and extending along the fin; and different forms of it are exhibited in different animals. There are, therefore, derivatives of the two outer strata of the ventral muscle, at any rate, contributing, and largely, to the muscular basis of the limbs.

A limb is usually composed of a series of cartilaginous or osseous pieces serially arranged and moveable upon one another, of which the fin of Lepidosiren is one of the simplest examples; and the instance of the paddle of Ceratodus has shewn that the muscular fibres pass from piece to piece, indeed that the muscular tissue of the limb is, in the primitive form, segmented into transverse planes corresponding with the axial cartilaginous, or osseous, segments, thus resembling the disposition of the muscles in the trunk, and more particularly in the tail, of simply constructed animals. But, as we have found in the trunk, the muscular fibres, the superficial fibres more particularly, are often not confined to their particular segments. They commonly break through the intervening barriers, or intermuscular septa, and range on to more distant segments, blending with the muscles of those segments. Hence the muscles of any division of a limb consist, usually, of three layers. *First*, and deepest, are the fibres of the segment itself, the 'intrinsic' fibres; of these the proximal series are the bundles passing from the girdle to the first segment of the limb: *secondly*, the fibres derived from distal segments, the 'extrinsic' fibres; and *thirdly*, and most superficially, the fibres derived from the ventral muscle, the superficial 'ventro-appendicular' fibres. The components of these three layers are blended together in a variety of ways, rendering it often difficult or impossible to distinguish to which layer they appertain.

In the simplest condition, as that of Lepidosiren, the cartilaginous or osseous pieces of the limb are joined to one another by simple tissue, and are moveable in any direction; and the muscular fibres are uniformly disposed around the joints, the deepest, or 'intrinsic', fibres forming a sort of circular capsule, and being blended on the exterior with the 'extrinsic' and the 'ventro-appendicular' fibres. When movements in particular directions are required, the conformation and structure of the joint is proportionately modified, and the muscular fibres are arranged and segmented, more or less distinctly, into bundles or muscles to effect the object. In the case of the proximal joint of the limb—that of the first cartilage or bone with the girdle—the movement is, on the whole, circumductory or in any direction; and the muscles are disposed around the joint in a nearly circular manner. Usually, however, even here, certain movements take place more frequently or more freely than others; and the muscular fibres are accordingly arranged in groups, or muscles, having more or less independent action. In the distal parts of the limb the movements are commonly much more restricted, are limited indeed, nearly or quite, to one plane, which is, speaking generally, the same for all the joints of the limb. They all admit cf flexion towards the palmar or plantar or ventral aspect, and of extension towards the dorsal aspect. Supposing the limbs stretched, as in their primitive condition, horizontally in straight lines and at right angles, from the trunk, then all the joints admit of flexion towards the ventral surface of the trunk and of extension to the horizontal line. At the wrist and ankle the extensor movement may, in some animals, be carried beyond that line (in Man the foot has come to be placed at a right angle with the leg); and the same is the case at the joints with the girdles where, as just said, other movements are also permitted. In all the joints, however, except that with the girdle, the movement is nearly restricted to the plane indicated. Hence the muscles are arranged in two sets, one upon the 'flexor' or 'ventral' aspect, which may also be called 'palmar' in the fore limb and 'plantar' in the hind limb, and the other set upon the 'extensor' or 'dorsal' aspect; and there is, speaking generally, a corresponding arrangement of the nerves.

It must not, however, be supposed that the arrangement is rigidly adhered to. Marginal portions of the ventral series occasionally (witness the *lumbricales*) stay upon the dorsal aspect and serve as extensors; and more frequently marginal portions of the dorsal series incline over the sides and upon the ventral aspect and serve as flexors, and perhaps become united with the flexors.

That there is a similarity, a general homological correspondence, between the muscles of the fore and of the hind limbs, as well as between the limbs of different animals, is self-evident. Their outer sheets are projections of serially homologous portions of the ventral muscle carried upon similar outgrowths from serially homologous ossifications in the ventral intermuscular septa[1]. The dorsal muscles of one limb and in one animal correspond, though not unexceptionably, with the dorsal muscles of the

[1] The septa in which the corresponding limb-girdles are formed are not, numerically, the same in the different orders of vertebrates. The scapular girdle, for instance, in the Fish is developed in a septum close to the head; whereas in the Bird it occupies a septum far removed from the head. So, the position of the pelvic girdle, though presenting a steady relation to the hinder part of the visceral cavity and the termination of the alimentary canal, varies greatly in its distance from the scapular girdle, owing to the variation in the number of intervening muscular and intermuscular planes in different animals.

other limb and in other animals; and the same with the ventral series. There is, moreover, often an antagonistic similarity between the ventral and dorsal muscles, according with the similarity in the action requisite to produce the flexor and the extensor movements. In short, the similarity of muscular disposition about the several joints, in the same or the different limbs of the same or different animals, is, as we might expect, generally proportionate to the similarity of the form, movements and position of the joints and of the force required[1]. Differences in these are sometimes, indeed not unfrequently, associated with such varieties in the combination of embryonic germs as to defy attempts at an exact homological comparison.

Two important features of difference which serve to modify the muscular relations in the two limbs at once suggest themselves as being present to a greater or less degree in most animals. First, the superficial position and the mobility of the shoulder-girdle, as compared with the pelvis; and associated with these are the variability and instability of the subglenoid parts of this girdle, and the frequent presence of a clavicle. The shoulder-girdle and its muscles often, indeed commonly, deviate from their simple primitive form and relations much more than do the pelvic-girdle and its muscles; and they are liable to much greater variations in position—fore and aft and in the depth of plane at which they are situated—and in their relation to the other parts of the osseous skeleton. In one animal the shoulder-girdle is joined to the head, giving it, in the opinion of some anatomists, a claim to be regarded as an appendage to the skull; in another animal it is joined to the vertebral spines; in a third to the vertebral bodies; in a fourth to the sternum; and in a fifth it is free from all these. These varieties in the girdle involve a greater amount of variety in the muscles connecting it with the rest of the trunk and passing from it to the limb, than is the case with the muscles of the pelvis. There is, however, in connection with the latter, the varying development of the tail, which leads to considerable

[1] I do not mean to assert that all muscular varieties are thus teleologically determined; but it is very generally so; and it is not easy to adduce unquestionable exceptions.

variation in the muscles passing between this part of the body and the pelvis and hind limb.

The second great feature of difference is the difference in the rotation of the two limbs; the dorsal surface of the thigh and knee being directed forwards, while that of the arm and elbow is directed backwards[1]. In the hind limb the leg and foot are involved in the same rotation as the thigh and knee. But the forearm and hand undergo a rotation in a different direction to that of the arm by means of the proation of the radius; so that the dorsal surface of the hand is directed the same way as the dorsal surface of the foot. The effect of these rotations is that the radial—or pre-axial—edge of the humerus looks outwards, and the tibial—or pre-axial—edge of the femur looks inwards. This leads to a difference in the insertion of some of the otherwise homologous muscles at the upper ends of the two bones, for instance, the radial tubercle of the humerus presenting on the outer side of the limb, receives the muscles from the dorsal aspect of the scapula and exceeds the ulnar tubercle in size; whereas the fibular tubercle of the femur rises into strong relief beneath the dorsum of the ilium, and receives the muscles which arise from that surface and exceeds the tibial tubercle in size.

I may observe that such a variation in the locality of the insertion of corresponding tendons in the two limbs, and indeed in the same limb in different animals, is by no means uncommon. It is seen in the instances of the extensor muscles of the leg and forearm, in the *extensores carpi radiales*, the *biceps brachii*, *latissimus dorsi*, &c. Too much importance has, I think, been attached to the insertion of a muscle as a guide to its homology: and the statement that the insertion is more to be depended upon, in this respect, than the origin is scarcely supported by observation.

We have already (p. 327) traced the ventro-appendicular muscles from the ventral muscle to the limbs, and pointed out their serial homological relations. It remains to follow them upon the limbs. Normally, or primitively, they spread, as in Lepidosiren, and less distinctly in Ceratodus, over the whole surface of each limb, forming an outermost muscular covering of the limb; and they are still seen to expand upon the distal segments in many even of the higher animals, especially in

[1] See my *Obs. on the Limbs of Vertebrate Animals*, p. 16.

the hind limb. But they are often reduced, in their course down the limb, to fasciæ or areolar fibres, and often are arrested by insertion into a projecting process of bone at some higher point; or they blend with, and are lost in, the subjacent strata.

To take first the 'palmar' and 'plantar', that is, the 'ventral' divisions of the ventro-appendicular muscle, which we call, respectively, *pectoralis* and *gracilis*. Each extends along the pre-axial edge of its limb, inclining to the palmar, or the plantar, surface. Each reaches sometimes to the distal segment, but is usually interrupted or lost earlier; and each blends in variable degrees with the subjacent muscles. The *pectoralis* is commonly arrested at the radial tubercle of the humerus; but, sometimes (Orycteropus), part of it accompanies the *biceps* to the radius, or (Otter and Wild Cat), together with some fibres of the trapezio-deltoid, accompanies the *brachialis anticus* to the ulna, or (Seal) expands into the fascia of the forearm and so reaches the hand. It is, in some instances, free from the subjacent muscles, and in others is blended with the coraco-brachials, or is connected with them by means of the *pectoralis minor* (see p. 344). The *gracilis* is rarely, if ever, arrested at so early a point as the pectoral. It is commonly inserted into the tibia, occasionally (Pteropus) blending with the *semitendinosus*, and, now and then (Unau and Aï), joining the *biceps flexor cruris* and acquiring an attachment to the fibula. It often extends down the inner side of the tibia, over the ankle and foot, spreading upon the dorsal and plantar surfaces of the foot (Seal). It is in some instances free from the subjacent adductors; in others (Cryptobranch) it is scarcely segmented from them.

The 'dorsal' divisions of the ventro-appendicular muscle have often a wider range than the 'ventral' both in their connection with the trunk and in the area of the limbs which they cover; and they are commonly sectorially segmented in some degree. The dorsal surface, as seen most distinctly in the fore limb of Dog-fish (Figs. 28 and 30) and in the hind limb of Ceratodus (Fig. 34), and the post-axial edge of the limb, may be regarded as their legitimate destination; but they not unfrequently spread, over both the pre-axial and the post-axial edges, upon the ventral surface of the limbs. They are, consequently, attached to various points. In the cylindrical (Lepidosiren), or rudimentary (Snakes), state of the limbs, they are not segmented from the palmar and plantar portions of the sheet, and are not themselves longitudinally or sectorially cleft.

In the fore limb there are usually two sectors of the dorsal division; one—the *trapezius*—converging from the dorsal aspect of the head and of the front of the trunk, and the other—the *latissimus dorsi*—converging from behind, upon the limb. The *trapezius* sector in branchiate animals (pp. 259, 273) is interrupted and devoted to the gill apparatus, and scarcely reaches the limb. In some animals, devoid of gills (Cryptobranch), it does not extend beyond the anterior edge of the scapular and the coracoid parts of the girdle. In others (certain Mammals) it runs on to the radial tubercle of the humerus, or to the radius, or even (Otter[1]) to the ulna, joining the flexors of the forearm. It usually presents an inscription as it passes over the shoulder. This inscription is the superficial part of the septum in which the girdle is formed; and, in Mammals, the anterior edge of the scapular part of the girdle, called the 'spine', commonly grows through the septum, so occupying the inscription, and bisecting the upper or supra-scapular part of the muscle, transversely, into posterior, or *deltoid*, and anterior, or *trapezius* parts. In the lower, or coracoidal, part of the septum the case is somewhat different. Sometimes the inscription (*i. e.* the remnant of the septum in the muscle) remains, and marks the division into *trapezius* and *deltoid* parts. Sometimes it is nearly obliterated. Sometimes it becomes ossified into a 'clavicle' or 'epi-coracoid' (p. 316), the ossification being (many Carnivora) confined to the deeper tract of it and limited in extent, or extending through the thickness of the muscle, and ranging, from the acromial end of the spine of the scapula, to the sternum[2]. The most important varieties, therefore, in this

[1] In an Otter the foremost fibres of the *trapezius*, continued as *deltoid* with an intervening inscription, and accompanied by some fibres of the *pectoralis*, descended in front of the *brachialis anticus* to the ulna.

[2] In Lizards the clavicle extends along the anterior edge of the scapula to its base. In Aï it is attached to the coracoid. In Fishes it is large, closely applied upon the coracoid, and meets its fellow in the middle line; but it is not certain that ossification ever extends from the coracoid into it. It seems in this respect to bear to the coracoid somewhat similar relations to those which the supra-, or better epi-, scapular bones (Parker's supra-clavicles) bear to the scapula. I have spoken of the clavicle as an ossification in one of the muscular septa of the brachio-cephalic stratum, corresponding with the epicostals. But it should be added that it is situated at a deeper level than they, in the deeper

trapezio-deltoid sector are; *first*, that in which it does not extend below the anterior edge of the girdle; *secondly*, that in which it extends beyond the edge of the girdle and its septum down to the humerus or forearm; *thirdly*, that in which it is divided transversely, in part or the whole of its width, into two distinct muscles by ossification extending from the edge of the scapular part of the girdle into the septum which traverses it and by ossification arising independently over the coracoidal part of the girdle. The portion of the *trapezius* which, in Cryptobranch, is inserted into the anterior edge of the scapula is, in Mammals, continued, beyond that edge, which grows up as the spine, into the scapular portion of the *deltoid;* and the portion which, in Cryptobranch, is inserted into the coracoid is, in Mammals, continued, beyond the coracoidal septum, or the clavicle which may form in it, on into the clavicular portion of the *deltoid.* These two portions of the *deltoid* are not unfrequently separate.

The sector in the hind limb, corresponding to the trapezio-deltoid, is recognisable as a distinct element only behind the pelvic girdle, where it forms the *sartorius* and the *tensor vaginæ femoris.* These are usually cut off from the *external oblique* part of the ventral muscle lying in front of them, which, or part of it, may be supposed to correspond to the *trapezius,* by the edge of the ilium; and they thus answer, serially, to the scapular portion of the deltoid. The *sartorius* is sometimes (Unau and Aï), like the *deltoid,* inserted into the pre-axial edge of the first bone of the limb; but, usually, it runs into the second bone. In other words, the *sartorius* usually continues its course on to the tibia, but is occasionally arrested at the femur[1]; whereas the *deltoid,* or part of it, occasionally (Orycte-

instead of in the superficial part of the stratum, as seen in Ps. Pallasii, and also in Carnivora, where the rudimentary clavicle is found in the deeper part of the septum between the trapezius and the deltoid. It has not unfrequently connections with the muscles of the subjacent stratum—the *subclavius* and the sterno- and omo-hyoids. It is extended between two cartilage bones, of which one (the sternum) is in a deep level. According to Gegenbaur, it is not without claim to a cartilaginous origin itself at one part; and it has a cartilaginous epiphysis. In short, it appears to afford an example of remarkable blending of the superficial membranous and the deeper cartilaginous ossifications, the former preponderating from a very early period, and in some instances, probably, constituting the only basis of the bone.

[1] The *sartorius* sometimes (Hippopotamus) runs down the middle of the dorsal aspect of the thigh, over the patella, and is lost there. In the Heron it

ropus) continues its course on to the radius, but usually is arrested at the humerus. The course of the *tensor v. f.* into the fascia does not distinctly correspond with anything in the fore limb. It is present only in Mammals, and is often wanting in them. The *sartorius* may (Rabbit) extend, along Poupart's ligament, to the *gracilis*, as the *deltoid* often extends, along the clavicle, to meet the *pectoral*. This is, however, rare; and the intermediate space between the two muscles in the retiring angle of the bend of the groin, where there is no 'point d'appui' for muscular action, is usually occupied by fascia. That fascia is, accordingly, the serial representative of the clavicular portions of the pectoral, deltoid, and trapezius, Poupart's ligament being the serial septal representative of the clavicle.

The posterior sector of the dorsal portion of the ventro-appendicular muscle in the fore limb—the *latissimus dorsi*—is, like the pectoral, a very general appurtenance to the fore limb in animals above Fishes. Even in Fishes it is sometimes (Dog-fish, Fig. 28) represented by a thin stratum segmented from the ventral muscle and passing upon the dorsum of the fin, the pectoral being in like manner segmented and passing upon the palmar surface of the fin. In Lepidosiren (Fig. 24) we have seen the *latissimus dorsi* and the *pectoralis* travelling forwards as a continuous sheet constituting the hinder part of the superficial brachio-cephalic stratum. In this animal the *latissimus dorsi* is attached to the scapular part of the girdle in addition to passing upon the fin; and in Dog-fish it is barely segmented from the deeper (*serratus*) part of the stratum which is also attached to the scapula. In Man, and some other animals, it still retains the scapular connection; and, as before (p. 319) remarked, it often retains its connection with the pectoral by axillary bundles passing from it to that muscle. It is traceable to variable points in the limb. In Lepidosiren its fibres run on with others to the extremity of the fin. In Urodelans it is blended with the *triceps;* and more or less of this union is often found in Mammals. In Saurians and Birds it passes, between the scapular and humeral origins of the triceps, to the radial edge of the humerus. In Mammals, passing internal to the tri-

is more separate from the *gluteus* than in most Birds, and some of its fibres are traceable into the *gastrocnemius*.

ceps, it is inserted into the ulnar edge of the humerus, sending often a *dorsi-epitrochlien* down to the ulnar condyle, or (Cyclothurus) extending along the fascia of the forearm to the ulnar side of the carpus[1], or (Manis) running into the *flexor sublimis digitorum*, or (Rabbit) into the *flexor carpi ulnaris*.

This muscle thus affords a very interesting illustration of the varying points at which a ventro-appendicular muscle becomes arrested in different animals, and the varying muscles of the deeper strata with which it becomes blended or, rather, with which it retains its connection.

It is worthy of remark that the fibres of this muscle, and also of the pectoral and, though less frequently, those of the deltoid, often cross one another in a remarkable manner; those which arise most posteriorly passing behind the others to an insertion in front of them, so causing a sort of twisting or folding-in of the lower edge and, sometimes, leading to a cleavage in the plane of the muscle. I have before called attention to this point (p. 296 and *Journal of Anat.* IV. 35).

The corresponding sector in the hind limb—the *gluteus maximus*—has relations as varying as those of the *latissimus dorsi*. Its connection with the ventral muscle is well exemplified in Dog-fish (Fig. 30), and Ceratodus (Fig. 34), as well as the mode in which, in a primitive condition, it extends upon the limb, and blends with the proper muscles of the limb[2]. From these animals upwards the connection with the ventral muscle rarely reappears[3]. Thenceforwards its chief attachment is to the ilium (which appears through the ventral muscle like the spine of the scapula) and to the neural spines and arches of the caudal vertebræ. In the lower animals it is often, as we have seen in Cryptobranch, so united with the *extensor cruris* as to be with difficulty distinguished from it; and in Birds it blends with that muscle in the thigh. The same connection exists, to a greater or less extent, in Mammals; though sometimes, as

[1] Representing the *costo-alaris* of the Bird (p. 319).

[2] It is not quite correct to speak of the muscle referred to in these animals as the *gluteus* sector only; forasmuch as it represents, rather, the entire undivided dorsal portion of the ventro-appendicular sheet. In Mammals also it is often undivided.

In anourous Batrachians and Saurians, this dorsal portion is a not distinctly segmented muscle.

[3] In Manis the dorsal portion of the ventro-appendicular muscle is largely developed, blending above with the external oblique and reaching to the lumbar spines, and below extending over the buttock and the fore and outer parts of the knee and thigh.

in Man, the connection is with the fascia covering the *quadriceps.* Like the *latissimus d.* it is, in addition, often inserted into the post-axial line of the femur; but it does not follow its homologue by occasionally passing, between the divisions of the extensor muscle, to the pre-axial line. It sometimes ranges along the margin of the ilium to unite with the *tensor v. f.* and the *sartorius,* so obliterating the division between the two sectors; and on the limb it often reaches the fibular malleolus and side of the foot.

Before concluding the account of the ventro-appendicular muscles, it is necessary to mention certain derivatives from the ventral muscle of the tail which belong to this series, some of which are not represented in the fore limb.

Of these, the first and most superficial is that which I named *Caudo-pedal* in the description of the Cryptobranch. It occupies an intermediate position between the *gluteus* and the *gracilis,* and descends along the plantar surface of the limb to the distal parts, blending with the flexors of the digits. In Fishes it is not distinctly represented; and in animals above Reptiles it is lost or represented only by fascial tissue in its upper part. Its lower part in these animals is probably represented by the *plantar fascia,* or the superficial layers of the plantar fascia, and, perhaps, by the superficial layers of the *tendo-Achillis* and by some fibres of the *gastrocnemius.* In the fore limb of Birds it seems to be serially represented by the *costo-alaris,* or its superficial fibres, which, as I have before said, is the antagonistic homologue of the *cervico-alaris* (*tensor plicæ alaris*). Such antagonistic homologue to the caudo-pedal in the hind limb we do not find. It would be represented by fibres from the external oblique, between the *sartorius* and the *gracilis,* passing down to the distal region of the limb[1].

Beneath, and connected with, the caudo-pedal is the *caudo-crural* of Cryptobranch, which fuses with the adducto-flexor mass passing to the leg, and more particularly with that part

[1] In Crocodiles a large muscle passes from the hindmost projecting point of the ilium; and at the ham its tendon is, partly, connected with the deeper muscles and, partly, extends superficially down to the foot. A segment of it internally joins the *gracilis.* Externally, it is in contact with the *biceps* and *gluteo-rectus.* I suppose it is the representative of the *caudo-pedal,* starting from the ilium as a fixed basis instead of from the caudal vertebræ.

of it which represents the *semitendinosus*, thus giving rise to, or causing the persistence of, an inscription which I have (p. 19) supposed to represent the inscription found in that muscle in Man and some Mammals[1]. The only trace of serial homologue in the fore limb to the caudo-crural would be fibres of the hinder portion of the pectoral, or fibres of the oblique or rectus, joining the biceps brachii. But none of them so coalesce with that muscle as to cause an inscription in it.

Both the caudo-pedal and the caudo-crural lose the transverse inscriptions where they separate from the ventral muscle in the tail; but there is in the retiring angle between the tail and the hind limb in Saurians a thick transverse fascial band, which I suppose to be an inscription between the caudal and the crural parts of these ventral, or ventro-appendicular, muscles, and which seems to correspond, antagonistically, with Poupart's ligament, and so, serio-antagonistically, with the clavicle.

Still deeper, and belonging to a deeper plane, is the *caudo-femoral*, which is usually present in ovipara above Fishes, and is sometimes designated *agitator caudæ*. It is inserted into the femur, and is, in varying degrees, blended with the deep muscles of the thigh—the *adductors* and the *semimembranosus*—and sometimes with the origin of the flexors of the foot and toes, affording an interesting example of the prolongation of the deeper strata of the ventral muscle to the distal parts of the limb.

The caudal derivations, which form so important an element in the muscular system of the hind limb of Urodelans and some Reptiles, are present, though less strongly developed, in Birds, and are not uncommonly met with in Mammals. Thus the *semitendinosus* sometimes derives its chief origin from the sacrum. In the Otter and Racoon, the *caudo-crural* is more distinctly represented by a muscular slip derived partly from the spinous and partly from the transverse processes of the caudal vertebræ. It joins the hinder surface of the *semitendinosus*, and is prolonged with the posterior fibres of that muscle

[1] In some large-tailed Mammals (Cyclothurus and Manis) the *semitendinosus* retains the caudal as well as the pelvic factors. I have not, however, found the inscription in any of these.

to the inner side of the heel. The caudo-femoral is also represented in the Otter by a thin muscle, arising from the transverse processes of the caudal vertebræ, passing internal to the sciatic nerve, and into the middle third of the linea aspera, between the gluteus and the adductors and distinct from both. The *pyriformis* and *quadratus femoris* muscles are both present in this animal. In the Rat a caudo-femoral muscle passes from the sacrum, beneath the *gluteus,* to the internal condyle and the post-condyloid bone, between the *addr. m.* and the *semimembranosus.* It lies near to, and in the same plane with, the *ischio-caudal.* The antagonistic homologues of the two (*caudo-femoral* and *ischio-caudal*) are probably the *psoas magnus* with its neighbour the *psoas parvus.*

The Muscles passing from the Limb-Girdles to the Limbs

may be regarded as extensions of the deeper strata of the ventral muscle—as deep ventro-appendicular muscles—forasmuch as the girdles are ossifications in the deeper level of the ventral inter-muscular septa. They share the surface of the girdles with the fibres of the ventral muscle which pass backwards or forwards to the adjacent trunk segments. Hence the extent of their attachment to the girdles varies inversely with the extent of attachment of the direct fibres of the ventral muscle. Where the latter are numerous, as on the ilium of Cryptobranch, the muscles passing from the bone to the limb are few. Where, on the contrary, the range covered by the direct ventral fibres is small, as in the pubischium of Cryptobranch, the size of the muscles passing to the limb is considerable. In like manner the extent of their attachment to the first segment of the limb reciprocates with that of the origin of the muscles passing to the second segment. Thus, in Cryptobranch, the *pectineus* engrosses the whole of the dorsal surface of the femur; whereas in most animals that surface is occupied by the extensor of the leg, and the *pectineus* is compressed within narrow limits. It may be inferred that the corresponding embryonic factors are, in some instances, employed in the building up of the one series of muscles and, in other instances, of the other series.

These muscles surround the joint of the first limb-segment with the girdle in a more or less circular, or capsular, manner. Usually, however, they are arranged in two divisions, or groups, in each limb. The one group passes from the outer, or posterior, surface of the girdle, beneath the joint, to the ventral or under surface of the limb, constituting a palmar' or coraco-humeral series in the fore limb and a plantar or pubischio-femoral series in the hind limb. The other group passes from the outer, or hinder, surface of the girdle, above the joint, to the dorsal surface of the limb, constituting a dorsal or scapulo-humeral series in the fore limb, and a dorsal or ilio-femoral series in the hind limb[1]. These groups do not adhere strictly to their respective limits. They sometimes extend from the outer surface, over the margins, upon the inner surface of the girdles; and they sometimes extend from the area of the girdle beneath the joint to the part above it, and *vice versâ*. Moreover, in accordance with the difference in the rotation in the two limbs, the insertion of corresponding muscles may be on the one—the pre-axial or radial—side in one limb, and on the opposite—the post-axial or fibular—side in the other limb. It not unfrequently is found, in the case of each of the several groups, that it is imperfectly segmented from the superficial ventro-appendicular stratum on the one surface, and from the muscles which pass on to the next segment of the limb on the other surface.

In animals above Fishes the CORACO-HUMERALS, or, as they are more generally called, CORACO-BRACHIALS, are commonly divided into segments which vary in number and size with the number and size of the coracoid processes; and they are sometimes absent when these processes are abortive, as in Mole, Cyclothurus and Seal. They arrange themselves in two divisions. *First,* those which lie superficially with regard to the *biceps brachii* muscle and which pass to the radial tubercle

[1] These are seen in their simplest form in Ceratodus (Fig. 34), where the coraco-brachial and the scapulo-brachial muscles are seen extending from the respective parts of the girdle upon the ventral and dorsal surfaces of the pectoral fin. The arrangements are similar in the hinder fin; and there are additions from the ventral muscle.

of the humerus immediately above the level of the *pectoralis major* and also extend beneath that muscle. These constitute a superficial or pre-axial division. *Secondly,* those which lie beneath the *biceps* and pass to the ulnar tubercle and ulnar side of the humerus. These constitute a deep or post-axial division.

The superficial division comprises the *epicoraco-humeral* and the *precoraco-humeral,* and probably the *supra-spinatus,* the *levator humeri* and the *pectoralis minor.* All these, with the exception of the last, which I will consider separately, may, I think, be regarded as parts of one muscle which occupies, essentially, the precoracoid process and might be called the precoraco-humeral muscle. It may spread upon the edge of the coracoid on the one side, and be segmented, so forming an *epicoraco-humeral;* and it may spread upon the supra-spinal space of the scapula on the other side, so forming a *supra-spinatus.* In Cryptobranch (p. 52), where the precoracoid processes are large, the *precoraco-humeral* muscle is well developed; and the *epicoraco-humeral,* in the same plane with and scarcely segmented from it, spreads over the edge of the coracoid; but there is no *supra-spinatus.* In Menobranch the latter muscle is present, in addition to the other two; but its edge is continuous with that of the *precoraco-humeral.* In the Scinc the *precoraco-humeral* and the *supra-spinatus* are large and separate; but there is no *epicoraco-humeral* extension of them over the broad origin of the *biceps.* In the Crocodile the *precoraco-humeral* is large, arising from the precoracoid process—from the outer surface and the anterior edge, and also from the deeper surface of that process—much as the *pectineus* often arises from the corresponding surfaces of the pubes. It is nearly on a level with *pectoralis* on the one side, and the *deltoid* on the other, and is inserted between them. The *supra-spinatus* is small, lies partly beneath it, and is imperfectly segmented from it. There is no distinct *epicoraco-humeral,* the surface of the coracoid, internal to the origin of the *biceps,* being closely covered by the *pectoralis* which derives some fibres from its edge, from the place, that is, where the *epicoraco-humeral* usually arises. In the Bird the precoracoid process does not run out distinctly. It is bent down with the coracoid to the sternum, forming an acute angle with the sternum; and the *precoraco-humeral* muscle follows it, together with the *epicoraco-humeral* factors. These, or some of them, extend upon the sternum and form the *levator humeri* or *pectoralis tertius*[1], as it is sometimes called. In Mammals the *supra-spinatus* and the *pectoralis minor* are the representatives of this division.

The fibres of the epicoraco-humeral part of this superficial, pre-axial, or supra-bicipital, division of the coraco-humerals lie immediately beneath the *pectoralis major* in its whole course. I have remarked that in Cryptobranch its superficial fibres are blended with the under surface of the pectoral, and that in Crocodile the fibres that correspond with it form part of the origin of the pectoral. It thus, to some extent, occupies the place of the *pectoralis minor;* and if we suppose it continued upon the under surface of the pectoral, and in variable degrees segmented from that muscle, it would quite correspond with the ordinary mammalian *pectoralis minor*, the proper insertion of which appears to be the radial ridge or tubercle of the humerus. It is, however, in Man and some animals, arrested wholly, or (Rat), partially, at the coracoid and is often quite segmented from the *pectoralis major*. Thus, I conceive the *pectoralis minor* to be formed from factors of the *pectoralis major*, which, or some of which, represent the *epicoraco-humeral* of Urodelans, Reptiles and Monotremes, and that it also in part represents, indeed is the nearest representative of, the *levator humeri* of Birds[2].

[1] Also the *secundus* when both are present.

[2] This view is in accordance with the fact that the *levator humeri* sometimes absorbs the *supra-spinatus*, or derives an accession of fibres from the upper surface of the scapula, as well as with the occasional passage in Man, as noted by Macalister, Wood and others, of the *pectoralis minor* over the coracoid process beneath the coraco-acromial ligament where it has been found to blend with the *supra-spinatus*, or with the capsule of the joint, or to pass directly to the head of the humerus. It harmonizes also with the close relation of the *supra-spinatus* to the tendon of the *biceps*, a relation corresponding with that of the *epicoraco-humeral* to the *biceps* in Urodelans and Reptiles.

It however is not quite in accordance with the view of Prof. Rolleston, *Trans. Linn. Soc.* XXVI. 609, that the *subclavius* is the homologue of the *levator humeri*. I have before (p. 315) given reasons for thinking that the *subclavius* is an extension of the middle stratum of the ventral muscle and is the serial homologue of the *costo-coracoid* muscle. It lies in front of, or above, the costo-coraco-clavicular ligament; and when it is prolonged beyond the range of the clavicle, it usually expands upon the *supra-spinatus* or the dorsum of the scapula, forming the *sterno-* or *sterno-costo-scapularis*, as it does in Hippopotamus and some other animals. Sometimes, however (Pig), it reaches the radial tubercle of the humerus; but its destination is rather to the dorsum of

The deeper, post-axial, or sub-bicipital, coraco-humerals arise from the coracoid beneath the biceps, as best seen in Reptiles. They may be traced, in these animals, taking origin from the under and hinder surface of the coracoid and spreading upon the under surface of the scapula, where a portion of them forms the *subscapularis*. In Mammals, this muscle is quite segmented from the others[1]. They are inserted into the ulnar edge of the humerus; it is inserted into the ulnar tubercle. The one next below the *subscapular*—the *coraco-br.-medius*—is generally present and is inserted into the middle of the shaft. The passage through it of the external cutaneous or musculo-cutaneous nerve indicates a tendency to division; and in several Mammals (Rabbit, Proboscis Monkey and Jerboa) the upper segment is inserted separately into the ulnar tubercle, forming a *superior coraco-brachial*. In Amphibians, Reptiles, and Monotremes there is commonly a third segment, an *inferior coraco-brachial*, which extends to the ulnar condyle; and the brachial artery with the median nerve passes between it and the middle coraco-brachial.

The PUBISCHIO-FEMORALS are less variable in number and size than their homologues just described, owing to the greater uniformity of the pubic and ischiatic bones in comparison with the coracoids. Like the coraco-humerals, they arrange themselves into superficial or pre-axial and deep or post-axial divisions, which pass, respectively, to the tibial and fibular edges of the femur; but the two are not so separated at their origin by the intervention of the prolonged portion which forms the flexor of the leg, as the two divisions of the coraco-humerals are separated by the prolonged portion of them which forms the *biceps* flexor of the forearm.

the scapula than to the humerus in the instances in which there is no clavicle, or when it extends beyond that bone.

The *pectoralis minor* would seem to be conducted as it were to the thorax in Mammals by the costo-coracoid ligament which usually separates it, above, from the subclavius, and which may be, as suggested by Gegenbaur, a remnant or representative of the extension of the coracoid to the sternum in ovipara.

In Pteropus (*Journ. Anat.* III. 301) a deep portion of the pectoral, which may be the *pect. minor*, arises from the clavicle. In the Rabbit, besides being connected with both tubercles of the humerus, it spreads over the *supra-spinatus*, and is inserted along the whole length of the spine of the scapula.

[1] In the Dog the *subscapularis* is partly blended with the *supra-spinatus*, and in the Mole with the *teres major*.

The superficial, or pre-axial, division of the pubischio-femorals comprises muscles arising from the os pubis (which is probably the representative of the precoracoid), and from part of the surface of the ischium (which is probably the representative of the coracoid). Owing to the large relative size and fixity of the bones from which they arise, and the heavier work which usually devolves upon the hind limb, they are ordinarily larger and more numerous than their correspondent the *precoraco-humeral* with its appendages, the *supra-spinatus* and the *epi-coraco-humeralis*, in the fore limb.

The *pectineus* is perhaps the most constant segment or muscle of the division, and it answers in many respects, serially, to the *precoraco-humeral.* It arises from the os pubis, and not unfrequently extends, over the anterior edge, upon the deep surface of the bone, much as the *precoraco-humeral* in Crocodile extends, over the anterior edge of the precoracoid, upon its deep surface. We have found the *pectineus* in Cryptobranch spreading over the dorsal surface of the femur, even to its fibular side. Usually, however, its insertion is limited to the upper part of the tibial line of the femur (the tibial edge of linea aspera). Where the ala, or anterior edge of the ilium, grows into prominence, an extension of this pubischio-femoral division spreads upon and occupies the anterior, or deeper, surface of the ala, constituting the *iliacus internus*[1], in the same way that an extension of the superficial coraco-humerals spreads upon the anterior surface of the spine of the scapula, and constitutes the *supra-spinatus.* Behind the *pectineus* lies the *adductor* mass, which is variously segmented in different animals and which is perforated by a vessel that in some animals becomes the main vessel of the leg and foot. It sometimes (Hippopotamus, Fig. 48, and others) extends upon the tibial side of the leg; and, we shall find presently, it often has intimate relations with the flexors of the leg[2].

[1] In Saurians the *iliacus int.* ranges, like the *pectineus* in Cryptobranch, but to less extent, over the dorsal surface of the femur, approaching the fibular side. In Mammals it is restricted to the tibial side.

[2] The adductor mass not unfrequently extends across the popliteal surface of the femur to the fibular line of the linea aspera; and a considerable part of it is probably derived from factors which, in the fore limb, range themselves with the post-axial division of the coraco-brachials.

The view just given of the morphological relations of the *iliacus internus* derives perhaps some confirmation from the fact that in the Hippopotamus, and other artio-dactyles and some other animals, there is an extension into the pelvis of one of the superficial muscles of the thigh—the *ilio-prétibien* of Cuvier. At least near the knee this muscle lies in the plane of the *sartorius* and the *gracilis* and seems, in some instances, to belong to the one, and in some, to the other of these two. In a Hippopotamus[1] the muscle I am alluding to was, near the knee, joined with the *gracilis*. Ascending, it diverged from it and divided into two portions. Of these, one was inserted into the inner edge of the brim of the pelvis, blending there with the lower part of the *psoas parvus*. The other portion expanded over the *iliacus internus:* the middle part of this was lost in the fascia covering that muscle; and the lateral parts, separating fork-like, approached and blended with the *psoas parvus* near its origin, on the one side, and with the outer fibres of the *iliacus int.* on the other side[2]. The *pectineus* was not distinctly segmented from the *adductors* in the Hippopotamus.

A remarkable derivation from this series of muscles, and apparently from the *pectineus*, is the *internal rectus* of Saurians and Birds. In the Cryptobranch we noticed the *pectineus* extending over the dorsal surface and fibular side of the femur; and the *internal rectus* would seem to be an extension of the lowest part of this, over the knee, beneath the *quadriceps*, into continuity with the flexors of the digits, an extension similar to that of a portion of the *peroneus*—the *p. longus*—over the ankle, through the sole, to the metacarpal of the hallux, or to that of the *tibialis anticus*, in Unau, over the inner side of the foot, into the flexor of the digits.

The deep, or post-axial division of the pubischio-femoral mass, which is inserted into the fibular edge of the femur and the fibular trochanter, is segmented into the *quadratus femoris*, the *gemelli*, and the *obturator externus* and *internus*. The

[1] Fig. 48 represents the muscles of the fore and upper part of the thigh and of the front of the pelvis, in a young Hippopotamus. *Il. i.*, iliacus internus.—*Ps. p.*, psoas parvus.—*Ps. m.*, psoas magnus.—*N*, the anterior crural nerve.—*I. p. t.*, ilio-prétibien.—*Ad. l.*, adductor longus.—*Gr.*, gracilis.—On the right side, the gracilis and ilio-prétibien have been removed, bringing into view more fully the psoas magnus, the iliacus internus and the adductor longus, also shewing (*Ad. m.*), the adductor magnus passing to the tibia, and (*S. t.*) the semitendinosus.—*S.* the sartorius.

[2] This extension upon the *iliacus* is described by Gratiolet in his *Mémoire*, p. 287, as the *Sartorius*. There is, however, a muscular band passing from the ant. spine of the ilium over the front of the patella, which appears to represent the *sartorius* and the *tensor vag. femoris;* occasionally the *gracilis* itself extends over the *pectineus*, and so comes into relation with the *ilio-prétibien* above, as this muscle comes into relation with the *gracilis* below.

obturator internus appears to result from an extension of the mass round the posterior edge of the ischium upon its internal surface, resembling the extension which we not unfrequently find of the *pectineus* upon the internal surface of the pubes; and the two divisions of the pubischio-femoral mass may thus meet on the internal surface of the pubischium. This extension of the *obt. int.* corresponds serially with the extension of the coraco-humeral mass upon the posterior and inner surface of the coracoid, a prolongation of which (p. 346) beneath the scapula forms the *subscapularis* and corresponds with the prolongation of the *obt. int.* beneath the ilium.

Instead of saying that the *obturator internus* is formed by an extension of the pubischio-femoral mass round the edge of the ischium upon its internal surface, it would be more correct to say that the fibres of the ventral muscle developed upon the inner surface of the pubischium blend posteriorly with, and so form an extension of, those on the outer surface. We sometimes find that they take a different direction, and blend with the muscles in front of the pubischium. Thus in Saurians they join the members of the pre-axial division and, uniting with the *pectineus* and *iliacus internus*, create an extension of those muscles in that direction. Again in Birds they take a third course and, converging to the fore part of the obturator foramen, run forwards, through it, to the fibular condyle.

This remark is applicable to other instances in which I speak of an extension of a given muscle over any particular territory. That extension is commonly effected by the fibres which belong to and are developed in the territory mentioned blending with the muscle which is extended over it. Accordingly, it will be commonly found that the nerve-supply to the so extended part of the muscle is derived from the sources which appertain to the region which it covers. I do not therefore attribute much importance to the fact of the internal obturator muscle being associated in its nerve-supply with the gemelli and quadratus, while the external obturator muscle is in the same way rather associated with the adductors and the gracilis.

The SCAPULO-HUMERAL and ILIO-FEMORAL muscles are, respectively, situated upon the dorsum of the scapula and of the ilium, and are, in the main, inserted into that surface of the proximal part of the limb, in each case, which is directed dorsally. This, in the primitive piscine condition of the limb (see Dog-fish and Ceratodus), is the dorsal surface. In most higher animals, however, the radial tubercle and edge of the humerus, and the fibular tubercle and edge of the femur, are turned into the position most favourable for their reception [1].

In the fore limb the scapulo-humeral mass is, in most of the lower animals, represented by a single muscle, diffused upon the dorsal surface of the fin in Fishes, but in Urodelans and Reptiles converging into a tendon implanted into the radial edge or tubercle of the humerus and called *dorsalis scapulæ*. This in higher animals is commonly segmented into *infra-spinatus, teres minor*, and *teres major*. It is probable that some of its superficial elements, which in certain cases apply themselves to the last-named muscles, in other cases apply themselves to and contribute to the formation of the *deltoid*. Hence we find the latter muscle occasionally (Phoca) encroaching upon the territory of these muscles and dwarfing them. The *infra-spinatus* and *teres minor* are sub-deltoid segments. But the *teres major* may rather be regarded as a *sub-latissimus dorsi* segment, forasmuch as it applies itself often to the under-surface of that muscle. At the same time it is more steadily connected than the *lat. d.* with the ulnar ridge of the humerus [2]. Both the *teres major* and the *supra-spinatus* sometimes (Pig) extend over the respective margins of the scapula upon the under-surface, and derive fibres which usually appertain to the *subscapularis*. The *teres major* does so more particularly; and its relation to this territory is also shewn by the fact that it and the hinder part of the *subscapularis* muscle are sometimes supplied by the same subscapular nerve.

The ilio-femoral mass forms the deep *gluteus* which is sometimes one muscle, but is often segmented into the *gluteus medius* and *minimus* and the *pyriformis*. The last is, in many instances, continuous with the *gluteus medius*. It commonly extends upon the under-surface of the ilium and upon the

[1] This I think is the real explanation of that difference in the insertion of those corresponding muscles in the two limbs which has caused so much difficulty in determining their homological relations. The view is confirmed by the observation that the muscles arising from the dorsum of the scapula are not strictly tenacious of their connection with the radial tubercle; some of them at least in Birds and Lizards passing to the ulnar tubercle, or the ulnar edge of the humerus.

[2] In Scinc it passes to the ulnar side of the humerus, quite separate from the *lat. d.* In Manis it is very large, blended with the *lat. d.* at its origin, and accompanies it to the inner condyle of humerus, the olecranon and the forearm.

sacral vertebræ. It lies beneath the *gluteus max.* bearing, at the origin, a relation to it similar to that of the *teres major* to the *lat. d.;* and the gluteal vessels and nerves pass between its anterior edge and the ilium, just as the posterior branches of the subscapular vessels and nerves pass between the anterior edge of the *teres major* and the scapula[1].

Thus the deep or girdle portion of the ventro-appendicular muscle in each limb divides itself more or less distinctly into sectors corresponding generally with, and often to some extent blended with, the sectors of the superficial stratum of the same muscle. The *coraco-humerals* in the fore limb, and the *adductors* in the hind limb, lie beneath, and are often respectively blended with, the *pectorals* and the *gracilis.* The *dorsalis scapulæ* presents similar relations to the *trapezio-deltoid,* and the *teres major* to the *latissimus dorsi;* and the same may be said, though less markedly, respecting the relations of the other corresponding muscles in the hind limb, viz., of the deep *glutei* with the *obliquus, sartorius,* and *tensor vaginæ femoris,* and of the *pyriformis* with the *gluteus maximus.*

THE FLEXORS AND EXTENSORS OF THE FOREARM AND LEG

are in each instance formed, *first,* by intrinsic muscles, that is, muscles arising from the humerus and femur; *secondly,* by extensions of the deep ventro-appendicular stratum, that is, by muscles arising from the girdle; and, *thirdly,* by extensions of the superficial ventro-appendicular stratum; and the muscles from these three sources are more or less blended. In the simple limbs of Fishes they form only one unbroken layer. Some amount of segmentation takes place in most other animals; but, owing to the simple nature of the movements they effect, the complications and varieties in these muscles are not very great or numerous.

The intrinsic flexors are represented by the *brachialis anticus*[2]

[1] See reasons, in *Journal of Anat.* v. 85, for regarding the *teres major* and the *pyriformis* to be serially homologous.

[2] In Hippopotamus the *brach. ant.* is wanting, the space on the outer side of the humerus from which it usually arises being occupied by the *sup. longus* which is large, and acts as simply a flexor. It might almost be described as *brach. ant.* inserted into the lower two-thirds of the radius instead of, as usual, into the ulna. The blending of the elements of these two into one is remarkable. The muscle winds round the back of the humerus to the inner side, and has a broad

in the fore limb, and by the short portion of the *biceps*—the *femoro-fibular*—in the hind limb. The latter is sometimes inserted low down in the leg (Cryptobranch and Cyclothurus)[1]. In other cases it meets and blends with the *biceps flexor cruris*, and is called the 'short' or 'femoral head of the biceps.' It is not unfrequently wanting. Both these are usually inserted into the post-axial bones of the limb—the ulna and fibula. The intrinsic dorsal or extensor muscles are represented by the parts of the *triceps* and of the *quadriceps* which arise from the humerus and the femur. They, in the fore limb, usually converge to the ulna and, in the hind limb, to the tibia.

The deep ventro-appendicular flexor—the flexor derived from the girdle—in the fore limb is the *biceps*, which presents variable degrees of continuity with, and segmentation from, the *brachialis anticus*, and which is further brought into continuity with the intrinsic series by means of muscular derivations from the humerus in the Bird, and not uncommonly, in other animals, including Man in whom they occur as a variety. These are generally from the ulnar side of the humerus; while the *brachialis anticus* extends chiefly from the radial side, between the deltoid and the triceps. The coracoid origin of the *biceps* and its relation to the coraco-humeral muscles have been already (p. 343) described. Those relations were found to be very close in Cryptobranch (p. 33), and they shew the *biceps* to be an intermediate between the *coraco-humerals* and the *brachialis anticus*, continuous with either or both, and uniting them into one group, which extends from the coracoid, along the ulnar and palmar surface of the humerus, to the radius and ulna[2]. When the coracoid reaches to the sternum the origin of the *biceps* is broad, expanding, fan-like, as it ascends; and sometimes

origin beneath the inner tubercle. It thus dwarfs both of the humeral origins of the triceps. It is supplied by the radial nerve.

[1] *Journ. Anat.* VI. 22 and IV. 56.

[2] They are all usually supplied by one nerve—the musculo-cutaneous—which is the homologue of the coracoid nerve of Reptiles, and the serial homologue of the obturator nerve. The *brachialis anticus* is sometimes (Pteropus) found to be in direct continuity with the coraco-humeral. In Scinc the *biceps* derives two factors from the humerus, which occupy the position of the *brachialis anticus*. They are so named by Rüdinger, see p. 35, and *Journ. Anat.* II. 301, III. 303, IV. 37.

(Owl) it shews a tendency to divide into two—an outer, or glenoid, and an inner, or coracoid part. The division is complete in most Mammals; and the coracoid part forms the more superficial element of the muscle. Where the coracoid is very short, however (Manis), the division may disappear. The *biceps* is inserted into either or both of the bones of the forearm.

In the hind limb the flexor derived from the girdle, omitting for the present the consideration of the *biceps* to which I will revert, may, as in Cryptobranch, be blended, in its whole length, with the adductor mass; and it is often united with it to some extent. It however has rarely, or never, any connection with the femoro-fibular muscle (the short portion of the *biceps*). It is in most animals divided, in its whole length, into two. Of these the *semitendinosus* is usually the more free from the adductors[1], is the more superficial, is inserted lower down on the tibia, and is the representative of the coracoid part of the *biceps brachii*. The other—the *semimembranosus*—is the deeper, represents the glenoid part of the *biceps brachii*, and is more connected with the adductors, presenting every degree of cohesion to them. It has also, as have the adductors, varied relations with the *caudo-femoral* which sometimes (some Birds[2])—blends with it, sometimes (Cryptobranch) runs to the femur quite separate from it, and sometimes (Saurians) sends a long tendon, separate from the *semimembranosus*, down to the back of the fibular side of the tibia, or to the fibula, or to a sesamoid just above the fibula, from which the flexors of the foot and digits arise[3].

[1] It retains a connection with the *gracilis* in Pteropus. In Seal the *semitendinosus* and *semimembranosus* remain one muscle, as their serial homologue the *biceps brachii* sometimes does in Mammals.

[2] In the Owl the *semimembranosus* and *adductor* are one muscle, which is joined by the *caudo-femoral*, and is partly continuous with the *gastrocnemius*. In the Swan the *caudo-femoral* joins the *adductor*, which is separate from the semimembranosus and is inserted into the linea aspera only. In the Gull the *caudo-femoral* is inserted into the femur unconnected with either the *semimembr.* or the *adductor*, which are separate; and the latter is partly continuous with the *gastrocnemius*.

[3] In the Dog the *semimembranosus*, arising from the tuber ischii, divides into two nearly equal portions. Of these one is inserted as usual into the tibia; and the other is inserted into the inner side of the lower part of the femur in the locality usually occupied by the *adductor magnus*. It is there blended with a tendon derived from the *add. longus*, and some fibres are inserted into the sesamoid of the inner head of the *gastrocnemius*. So that the sesamoid behind the internal condyle is a meeting-point between the *adductors* and the inner

The intrinsic extensors are represented by the parts of the *triceps extensor brachii* and the *quadriceps extensor cruris*, which arise from the humerus and femur, and which are very constant (except in Cryptobranch) and are subject to but little variety. The deep ventro-appendicular, or girdle, element is furnished by the scapular origin of the *triceps*, and by the *rectus femoris* or iliac origin of the *quadriceps*. Both these are connected with the dorsal surface of the girdles near the joints with the limbs; but the rotation of the fore limb usually directs the origin of the *triceps* to the hinder edge of the scapula, and the rotation of the hind limb directs the *rectus femoris* to the anterior edge of the ilium[1]. The superficial ventro-appendicular element is furnished in the fore limb by the *latissimus dorsi*, which in Cryptobranch is quite lost in the *triceps* and, in other animals, is partly blended with it; though, in Man and some Mammals, it passes to the humerus and has no connection with the *triceps*[2]. In the hind limb this element

head of the *gastrocnemius;* just as the sesamoid behind the external condyle is a meeting-point in Lizards between the tendon of the *caudo-femoral* and the outer head of the *gastrocnemius.*

Some of the fibres of the tendon of the *adductor magnus* in ourselves are continued into the internal lateral ligament, and so reach the tibia. In Aï and Manis some fibres of the *semimembranosus* join the *add. m.* above the knee. In the Jerboa the two muscles are inseparably united, and are inserted by a continuous tendon into the femur, the tibia, and the side of the knee. In the Rabbit the *adductor* is inserted into the tibia, as well as into the femur. In the Hippopotamus the *semimembr.* continues in union with the adductor as far as the knee.

[1] In Bats the rotation of the hind limb is the reverse of what is usual; and in Pteropus I found the *rectus* arising from behind the acetabulum. *Journ. Anat.*, III. 312.

The *triceps* in Manis extends in conjunction with the *supinator longus*, upon the dorsum of the scapula and to the spine, lying over the *teres* and *supraspinatus:* and, in Batrachians and Reptiles, the *triceps* derives an origin, behind, from the coracoid, as, in the same animals, the *quadriceps* derives an origin in front from the pubes. In Scinc the long portion of the triceps divides, one part passing external to the *teres major* upon the dorsum of the scapula, and the other upon the under surface of the shoulder-joint and the coracoid.

In Phoca (*Journ. Anat.*, II. 302) a portion of the triceps (*dorsi-epitrochlien*), blended above with the scapular origin, and arising from the angle of the scapula, passes by the olecranon, along the ulnar side of the paddle, to the 5th digit. It forms a sort of intermediate between the *triceps*, the *teres major*, the *latissimus dorsi*, and the *costa alaris* of Birds, linking them all together and being linked by the two last to the ventral muscle.

For the parallel between the relations of the *triceps* to the radial nerve and those of the *biceps flexor cruris* to the peroneal nerve, see p. 53.

[2] The mode in which the *lat. d.* blends with the *triceps* in Cryptobranch explains its varied relations with that muscle—its passing in some instances on one side and in some on the other side of the scapular origin for instance—the fact being that its fibres are in some animals diffused in the *triceps;* in

is furnished by the *gluteus maximus*, which, in Birds, is blended with the quadriceps, and which, in Cryptobranch and other Batrachians, does not exist as an element distinct from the *rectus*[1]. In Mammals it partly expands into the *fascia* overlying the *quadriceps*, and partly is inserted into the fibular line of the femur. Sometimes it extends upon the outer side of the leg to the ankle and foot.

I have shewn (p. 22) that in Cryptobranch the long, or chief, portion of the *biceps flexor cruris* is a derivative from the *gluteo-rectus*, that is, from the blended, or unsegmented, superficial and deep ventro-appendicular extensions upon the dorsum of the limb; and that it inclines upon the lateral surface and plantar aspect of the limb, so as to acquire a flexor action. It often shews traces of this its origin. It retains its connection with the ilium in Lizards and Birds, being overlapped by the *gluteo-rectus* in the latter. In Mammals also it is often continued upon the ilium through the sacro-sciatic ligament. Not unfrequently it has more direct connection with that bone; and in some it extends, in close relation with the *gluteus*, upon the caudal vertebræ[2]. The inclination of this segment from the dorsal to the plantar aspect of the limb, and at the same time from an extensor to a flexor function, is probably due to the direction of the rotation of the limb. Accordingly, there is an absence of any distinct representative of it in Bats; and the nearest approach to the formation of a similar muscle in the fore limb is presented by the *dorsi-epitrochlien*—by such a one especially as we find in the Seal (see footnote, p. 354). It

some they converge to and penetrate it at one point, in some at another; and in some they converge to, and pass on one side of it.

[1] In Birds there is no distinct *rectus femoris;* that is to say, this part of the quadriceps is not segmented from the *gluteus* or, as it might be called, *gluteo-rectus.* This is also the case in Urodelans (p. 22) and is paralleled by the imperfect segmentation of the *latissimus dorsi* from the scapular origin of the *triceps* in these animals (p. 36).

[2] In Orycteropus and Otter, the *biceps* arises from the ilium, ilio-sacral ligament and sacrum. In a wild Cat it was joined near the middle by a slip from the caudal vertebræ just behind the *gluteus.* In a tame Cat this slip, broad at its origin, was continued by a thin tendon which passed between the *vastus externus* and the *biceps* to the *fascia* on the outer side of the knee. In the Rabbit the chief origin of the biceps is from the sacral and caudal vertebræ; and it expands over the fibula and outer side of the leg, as far as the heel, without being inserted into the fibula. In Hippopotamus its disposition resembles that in the Rabbit; but it is more blended with the *gluteus* and has an insertion into the fibula. In Seal it reaches to and blends with the extensor tendons on the dorsum of the foot.

seems in many cases to be segmented from the *gluteus*, much in the same manner as the dorsi-epitrochlien is segmented from the *latissimus dorsi*.

Portions of the *triceps*, at the lower part of the arm, are not unfrequently segmented on one or both sides, constituting the *anconeus externus* and *internus*. A similar segmentation does not take place in the case of the *quadriceps*.

A sesamoid is very often developed in the lower end of the *quadriceps* and occasionally (Pteropus) in the lower end of the *triceps*. In the Wombat and a few other Marsupials the usual tibial sesamoid—the patella—is absent and a sesamoid—the fabella—is found upon the upper end of the fibula. We may connect this with the relation just described between the *biceps* and the *quadriceps*. The fabella can scarcely be regarded as the homologue of the patella, being connected with a different bone and a different part of the dorsal muscle. It presents more claim to be the serial homologue of the sesamoid in the *triceps*, situated above the olecranon which is the homologue of the large process growing from the upper part of the fibula in Monotremes. The connection of the fabella with an outlying portion only of the dorsal femoral muscle, whereas the supra-olecranon sesamoid is connected with the middle portion of the dorsal humeral muscle, is explained by the fact that the greater part of the femoral muscle is directed upon the tibia, whereas the greater part of the humeral muscle is directed upon the ulna.

The insertion of the *triceps* into the ulna while the *quadriceps* is inserted into the tibia has caused, in the mind of some anatomists, an unwillingness to admit the serial homological relation of the two muscles. The force of this objection, however, diminishes as we learn more of the manner in which the points of insertion as well as of the origin of muscles are liable to variation and to wander from one bone to another.

To sum up as thus far traced. The dorsal extension of the ventral muscle upon the hind limb gives rise to the *gluteus magnus*, the *tensor vaginæ femoris* and the *sartorius*, to the *rectus femoris* and the long part of the *biceps*, to the *pyriformis* and the *glutei*. The like extension upon the fore limb gives rise to the *latissimus dorsi* and the *trapezio-deltoid*, the long head of the *quadriceps* with the *dorsi-epitrochlien*, to the *teres major* and *minor* and the *infra-spinatus*. The plantar extension of the ventral muscle upon the hind limb gives rise to the *gracilis* and the adductors, including the *iliacus internus* on the one side and the *obturators*, *gemelli* and *quadratus femoris* on the other, together with the *semitendinosus* and *semimembranosus*.

The same upon the fore limb gives rise to the *pectorales* and the coraco-brachials, including the *supra-spinatus* on the one side and the *subscapularis* on the other, together with the *biceps*.

Middle and Distal Segments of the Limbs.

The muscles on the ventral (palmar and plantar) and on the dorsal surfaces of these segments of the two limbs are, in each instance, as we learn from the lowest orders of Vertebrates (see Figs. 23, 24, 34 and 36 and Cryptobranch), in their primitive state, in one mass which is connected with, that is to say, is to some extent continuous with, the prolongations of the ventral muscle upon the limb. In animals above Fishes, in all of which a uniform plan of segmentation of the limbs is followed, each mass (palmar or plantar and dorsal) is usually attached to the bone of the upper segment of the limb and to the several bones of the middle and distal segments. In accordance with the feathering manner in which the limbs, especially in the lower animals, are pressed upon the ground and withdrawn from it, the fibres on the palmar and plantar surfaces are directed from without, inwards as well as downwards, take their origin chiefly from the post-axial (ulnar or fibular) condyle and the post-axial side of the limb, and constitute a 'pronato-flexor' mass in each limb; while the fibres on the dorsal aspect, having a supinato-extensor action, take a similar direction, passing downwards and inwards from the post-axial side of the limb, and in some instances, in the hind limb, from the dorsal part of the post-axial condyle of the femur. In the case of the fore limb, however, the ulna, rising into the olecranon, commonly shuts off the supinato-extensor mass of muscles from the post-axial condyle of the humerus, and causes it—the deep as well as the superficial layer of it—to spread upon the preaxial condyle and the preaxial edge of the humerus. A certain method of division of these masses into planes and sectors is common to them all, and is also common to them in most animals; though there are of course many varieties in detail. A part of either of the masses which associates itself with one plane or one sector in a certain limb or animal may be otherwise disposed in other cases; but the deviations are on the whole fewer and less than might have been anticipated. As a general rule each mass is divisible into a superficial and a deep stratum; and the superficial stratum is divisible into three sectors—two lateral and a median—though the division is by no means equally complete in all instances, that is to say, in some animals, as Cryptobranch, the segmentation is much less advanced than in others. It is usually less distinct in the pronator-flexor mass of the hind limb than in the several other masses. There is considerable variation in the extent to which the several masses are blended with the muscles of the upper segments of the limbs and with the extensions of the ventral muscles—the ventro-appendicular muscles—upon the limbs. The blending of the muscles of the upper segments is more observable on the palmar and plantar than on the dorsal aspects, because the dorsal projections of the elbow and knee commonly interrupt the continuity between the muscles above and below those joints.

Pronato-flexor Masses.

The superficial stratum of these in Cryptobranch is very imperfectly segmented from the deep strata in both limbs; and in the hind limb it shows very little trace of division into sectors. In that limb it is a simple scarcely segmented mass extending from the fibular condyle and the fibular side of the limb upon the tarsus and digits. Superficially, it is continuous, through the medium of the *caudo-pedal*, with the superficial prolongation of the ventral muscle. This connection is in Lizards maintained only by a delicate tendon, and in higher animals does not exist; but the extensions of the *gluteus* and *biceps* are often substituted for it. The deeper (caudo-crural and caudo-femoral) prolongations of the ventral muscle are directed chiefly to the tibial side of the limb and do not commonly connect themselves with the pronato-flexor mass. Such a connection is however, as already mentioned, established in some Lizards by the descending tendon from the caudo-femoral running into the sesamoid above the fibula, from which the flexors of the foot and toes in part arise; and in some Birds there is a similar connection of the same muscle with the inner head of the *gastrocnemius* through the medium of the *semimembranosus*. In Manis the inner head of the *gastrocnemius* derives fibres from the *adductor magnus;* and we know that this muscle is sometimes intimately connected with the caudo-femoral in the animals in which the latter is present. Moreover, the *rectus internus* in Birds and Lizards is continued over the condyles of the femur into the fibular origin of the superficial flexor of the digits, affording a good illustration of the manner in which, from the primitive unstratified unsegmented homogeneous envelope of the limb-skeleton, special forms are evolved.

Continuing the investigation of this superficial stratum of the pronato-flexor mass in the hind limb, in the which, as just said, the caudo-pedal is blended, we find it in the lower animals where the foot is in a plane with the leg extending, for the most part, to the digits. As the heel grows out, however, the superficial pronato-flexor stratum becomes concentrated upon and more or less interrupted by it.

The *plantar fascia*, which represents the pedal part of the caudo-pedal, may thus become isolated—cut off by the projecting os calcis—from the crural fascia and from the superficial layers of the *tendo-Achillis* and *gastrocnemius*, which appear to represent the crural part of the caudo-pedal. The pedal part of the *flexor sublimis digitorum* may become, in like manner, cut off from the crural part, the former acquiring the name of *flexor brevis* and the latter that of *plantaris*. The rest of the stratum, uniting itself with the caudo-pedal and inserted into the os calcis, forms the *tendo-Achillis* with the *gastrocnemius* and *soleus*. The degree however of this calcareal interruption of the superficial pronato-flexor stratum varies. The *tendo-Achillis* is sometimes continued into the plantar fascia; and the continuity of the *flexor sublimis digitorum* from the femur to the digits, as well as its connection with the plantar fascia, is very frequent[1]. In ourselves the principle of concentration of force upon the heel is carried to the utmost. The pedal and crural parts of the stratum are quite isolated from one another by the os calcis; and addi-

[1] In Phoca (*Journ. Anat.* II. 314). The elements of the *flexor sublimis* are derived from the *plantaris*, the *gracilis*, the *flexor profundus* and the *tibialis posticus*. In Unau also it derives a factor from the *tibialis posticus*. These are interesting remnants of the primitive common basis from which the several muscles were segmented.

tional power is brought to bear upon the heel by the origin of the *soleus* from the tibia and by the great development of the bellies of the *gastrocnemius.*

Thus considered, the *gastrocnemius* consists of the blended factors of the *caudo-pedal* and of the superficial layer of the pronato-flexor mass, some of which—the *soleus* elements—pass from the fibula, with occasionally factors from, or a connection with, the caudo-femoral. Most of these descend from the fibular side of the limb. In Amphibians the fibres that do so make up the whole muscle; and there is nothing to correspond with, or represent, the inner or tibial head of Birds and Mammals. This makes its appearance in Saurians as a thin muscular band descending from the lower edge and outer surface of the superficial plantar mass of the thigh—the part which represents the *gracilis* and *semitendinosus*—to the tibial side of the surface of the *gastrocnemius.* In Birds the tibial origin is connected rather with the portion which forms the *semimembranosus* or the *adductor;* and it acquires also a connection with tibial condyle of the femur. In Mammals the relation to the muscles descending from the thigh is lost, and the connection with the femur only remains, supplemented in Man by an origin from the tibia which constitutes the inner or tibial portion of the *soleus.*

The spreading of the *gastrocnemius* upon the fore part of the tibia in Birds, where it in some (Heron and Gull) is partially blended with the *sartorius*, is another illustration of the connection or continuity of the flexor with the extensor, or the plantar with the dorsal, muscles, and of the encroachment of one group upon the area of the other, of which we have seen so many instances. This portion of the muscle, though separated from the remainder by the *semitendinosus* passing between it and the internal condyloid head, is supplied by the popliteal nerve.

The blending of the *sartorius* with the *gastrocnemius* above mentioned is an interesting example of that continuity of the extensor and flexor muscles of the same limb, which is more remarkably exemplified, in a deeper stratum, by the continuity of the *internal rectus* with the *flexor digitorum.* Both subserve the same purpose, viz., that of assisting the action of the femoral flexors of the foot and toes during the condition of forced flexion of the knee which is so often and long maintained in Birds, and during which those flexors are much relaxed and less capable of acting upon the digits.

In the fore limb the superficial stratum of the pronato-flexor mass never acquires an origin from the radial condyle, such as would correspond with the tibial head of the gastrocnemius which we find in the hind limb of Birds and Mammals. The covering fascia, strengthened by prolongations from the *pectoral* and *biceps*, perhaps also from the *latissimus dorsi*, and sometimes strengthened by muscular fibres derived from the ulnar condyle which constitute the *palmaris longus*, is the representative of the caudo-pedal. The most distinct example of a prolongation of the ventral muscle upon the palmar aspect of the fore limb—the most distinct serial correspondent, in short, of the caudo-pedal—is, however, as stated p. 319, furnished by the *costo-alaris* of Birds[1].

Forasmuch as the carpus retains in all animals the flattened form, there is not here, as in the hind limb, a tendency to concentration upon a heel-bone thrown up in the middle, or an interruption of the several muscles by such a process. The components of this stratum are, therefore, more equally disposed upon the surface as they descend, than those of the hind limb; and they present a more distinct division into ulnar, radial and intermediate sectors. Of these the ulnar sector (*flexor carpi ulnaris*[2]), inserted into the cuneiform (with the pisiform) bone which is the homologue of the os calcis, is the chief representative of the *gastrocnemius* and *soleus*. In the intermediate sector, the *palmaris l.* expanding into the palmar fascia, where it blends with fibres of the *flexor carpi ulnaris*, represents the superficial part of the *gastrocnemius;* and the *flexor sublimis digitorum*[3] represents the *plantaris* and the *flexor brevis*

[1] I have said that the *costo-alaris* is to some extent the serial representative of the *caudo-pedal*, and that the *palmaris l.* is also a like representative of the same muscle. An interesting exemplification of the relation of these parts is afforded in Phoca by the *palmaris l.* which, instead of arising as usual from the condyle of the humerus, passes upon the olecranon and blends with a portion of the *triceps* coming from the angle of the scapula, which again is in close connection with the *latissimus dorsi;* and it spreads like the *costo-alaris* upon the ulnar side of the carpus and hand. The similar exemplification in Manis afforded by the direct continuity of the *latissimus dorsi* with the palmar fascia and the *flexor subl. dig.* has already been pointed out.

[2] The *fl. c. u.* is not subject to much variety. It sometimes (Unau and Cyclothurus) spreads across the wrist superficially, meeting an expansion from the *supinator longus;* or (Phoca) it spreads beneath the *palmaris l.;* or it blends with the latter muscle or with the annular ligament. In the Proboscis Monkey it meets the *sup. l.;* and the expansion formed by them lies superficial to, and can be dissected off from, the fascia of the forearm.

[3] The *fl. d. s.* is partially interrupted at the carpus in Pteropus; and the *palmaris l.* in Aï. In Scinc the *fl. d. s.* is tendinous at the wrist and expands

digitorum which, as already shewn, are the upper and lower parts of the *fl. s. dig. pedis.* In the hind limb, the last-named muscle becomes, in higher animals, almost pushed out of the field, being reduced to the slender *plantaris* by the increasing gastrocnemius. But in the fore limb its homologue is in the ascendant and absorbs a great part of the fibres of the stratum at the expense of the *flexor carpi ulnaris* and also of the *palmaris l.*, which latter dwindles or disappears. The tibial sector of the superficial stratum in the hind limb shares the fate of the other parts of the stratum; indeed it is altogether absorbed by the heel muscle. In the fore limb the corresponding sector is large, is partly inserted along the radius, forming the *pronator radii teres,* and partly into the carpus or metacarpus, forming the *flexor carpi radialis.*

Thus, granting that the *plantaris* is represented by the *flexor digitorum sublimis*, the elements of the stratum which, in the hind limb, are made to converge into the *tendo-Achillis* are, in the fore limb, divided into the *palmaris longus*, the *flexor carpi ulnaris* and the *flexor carpi radialis* with part of the *pronator teres.* Moreover the *palmaris l.*, instead of being interrupted at the carpus, is continued into the palmar fascia; just as the homologous part of the stratum in the hind limb is continued into the plantar fascia in those animals in which the tarsus retains its primary simple, flat, carpus-like form.

I have before (p. 37, 38) pointed out evidences of the continuity of the upper (*pronator teres*)[1] part of the radial sector of the superficial stratum with the deepest (*pronator quadratus*) part of the deeper stratum; and the lower or *flexor carpi radialis* part of the sector is, in most animals above Urodelans, separate from the *pronator teres* and takes a deep course in the hand[2]. Now we find in the hind limb that the whole of the representatives of this sector—the representatives, that is, of the *pronator teres* and the flexor *carpi radialis*—or

into a second muscle below the wrist; thus closely simulating the *plantaris* and *fl. d. s.* in the ordinary mammalian hind foot.

[1] The ulnar origin of the *pronator teres* in Man (also in the Chimpanzee and Rabbit) is an interesting remnant of this continuity. In the Bird (Kite) the muscle is in two distinct parts, both arising from the humerus. Some of the branches of the median nerve pass between, some above and some below, the two parts. The branches passing between them are distributed to the *fl. c. u.* and the *fl. dig. pr.* and represent, therefore, part of the ulnar nerve. See disposition of the muscle and its relation to nerves in the Cryptobranch, p. 37.

[2] In the Bird the *flexor carpi radialis*, like its serial homologue—the *tibialis posticus*—lies deep in its whole course. It arises from the ulna only and not from the humerus. See varieties of insertion into scaphoid and mets. I., II., and III. *Journ. Anat.*, IV. 42. In Phoca it is inserted into the scaphoid and Met. I. with a slip to Met. II.; in the Pig into Met. III.; in the Proboscis Monkey into Mets. II. and III.

such of them as are present, viz., the *popliteus* and the *tibialis posticus*, are situated in a deep level, nearly in the same level with the *pronator tibiæ quadratus* with which indeed the *popliteus* is sometimes merged. That is to say, the radial sector, though chiefly in a superficial level, is continued into a deep level through the medium of certain fibres of the *pronator teres* and through the tendon of the *flexor carpi radialis*; whereas the tibial sector, composed of the *popliteus* and the *tibialis posticus*, lies throughout in a deep level.

Indeed, the greatest and most essential features of difference with regard to this region in the two limbs is caused by the fact that the *flexor carpi radialis*, which in the hand lies in as deep a level as does the *tibialis posticus* in the foot and evidently corresponds with it, becomes in the forearm part of the superficial stratum and is attached to the condyle of the humerus; whereas the *tibialis posticus* continues its deep course in the leg and does not reach the femur at all. The plane of segmentation of the two muscles, which is the same in the hand and foot, differs in the forearm and leg. So that, although the two tendons might be regarded as serially homologous, the two muscles can scarcely be said to be so. Properly viewed, however, they furnish a good illustration of the way in which certain nearly corresponding muscles in the two limbs (and the remark applies to muscles of the same limb in various animals) are differently segmented from the parent mass. They afford further evidence that homological rule is not so rigidly followed in development as we may be disposed to think, and that we must not be too severe in our attempts to institute homological comparison.

The variation that occurs in the division of the strata and in the amount and disposition of the fibres attaching themselves to either stratum, is also shewn by the fact that in the lower animals the fibres of the radial and ulnar sectors are in great part inserted into the radius and ulna, so becoming flexors of the forearm upon the arm; and superficial prolongations only of them pass on to the carpus; whereas in higher animals the ulnar sector arising partly from the ulna is continued in its entirety to the carpus, and the radial sector divides into two parts, of which one—the *pronator teres*—is inserted into the radius, and the other—the *flexor carpi radialis*—is continued to the carpus.

The differences in the two limbs evidently have relation to the necessity that exists in higher animals for moving the foot forcibly as a whole for the purpose of driving the body onwards. This is accomplished by throwing the whole or the greater part of the strength of the superficial stratum of the pronato-flexor mass, including the elements of the caudo-pedal, upon the projecting lever furnished by the os calcis, and by applying a portion of the deeper stratum of the mass (*tibialis posticus*) to the same end as well as to the pronation of the limb; whereas in the fore limb the whole of the deep stratum, except the *pronator quadratus* and a considerable part of the superficial stratum, is available for the movements of the digits, and so subserves more directly to prehension and the requirements of the will. In the hind limb the muscular mass becomes absorbed by the elevator of the heel, and in the fore limb it becomes absorbed in the flexors of the digits.

Not only does the superficial flexor of the digits in the fore limb absorb nearly all the elements of the middle sector, and push the *palmaris l.* (the representative of the middle or superficial part of the gastrocnemius, including the caudo-pedal) nearly or quite out of the field; but it not unfrequently happens that it in turn gives place, in great measure, to the deep flexor. Thus it may be reduced (Hatteria), much like its homologue in the hind limb of Man, to a mere thin muscle, arising near the wrist from a ligament extended between the *os pisiforme* and the *os naviculare*, or (Unau) it may be a mere slip from the deep flexor, or it may (Phoca) be imperfectly segmented from the *palmaris*[1].

As a prelude to further analysing and reducing the pronato-flexor masses and entering upon the consideration of their deeper strata, we must remember the numerous skeletal moveable parts in the distal region of each limb, and must conceive an unsegmented chaotic muscular mass passing from above downwards, and dropping fibres upon and deriving

[1] In Carnivora, where it is usually small and often imperfectly segmented from the *palmaris*, the superficial fibres of its tendons commonly blend with the palmar fascia and pass into the pads and the skin; and the deeper fibres form the perforated tendons to the phalanges. In the hind limbs of a Dog and of a Cat some of these fibres to the pad were derived from the *fl. prof.* and passed between the tendons of the *fl. subl.* Delicate muscular slips also passed from the deep to the superficial flexor tendons in the sole of these animals.

In Jerboa the *flex. subl.* passes to the three middle digits only; the other digits (I and V) receiving delicate muscular superficial flexors from the supernumerary carpal ossicle which is present in that animal. These, like the same muscular Hatteria, remind us of the usual disposition of the *fl. subl.* in the hind limb. In Guinea Pig the superficial flexor sends the greater part of its tendon to join the *fl. prof.* The superficial flexor to digit V. is formed on the radial side by a tendon from *fl. prof.* and on the ulnar side by a small muscle arising from the palmar fascia. In short, the varieties in the segmentation of these muscles are very numerous.

In the Heron and some other birds, the *fl. d. s.* is little more than a tendon passing, from the int. condyle and the cuneiform bone, to the fascia and the proximal phalanx (it passes to the second phalanx in the Swan). In the Jackdaw it is a muscular slip from the *flexor carpi ulnaris*. In the Rook it is a separate small muscle arising by a tendon from the int. condyle and passing partly into the *fl. c. u.* and partly to the proximal phalanx of the digit. See varieties in disposition and relations between the deep and superficial strata, *Journ. Anat.* IV. 43. In Manis the superficial flexor passes to the pollex and is continuous above with the *latissimus dorsi*.

fibres from the several skeletal parts after the manner which is suggested by the anatomy of the limbs in Fishes and in Cryptobranch.

In the Cryptobranch, segmentation has gone to a certain extent. Take the hind limb. *First,* the superficial fibres pass the farthest, extending from the femur, indeed from the tail, to the terminal phalanges, and they form a superficial stratum; still this stratum is very imperfectly separated from the deeper portion of the mass. *Secondly* (Figs. 9 and 11), a band is segmented from the deep part of the mass and is directed upon the bases of the digits, forming a *flexor profundus digitorum.* *Thirdly* (Fig. 12), several small deep bundles are segmented, passing from one skeletal part to another near by, so constituting 'intrinsic' muscles—*tarso-metatarsales, metatarso-phalangei, phalangei* and *intermetatarsales* or *interossei.* The residuum of the mass constitutes what I have called the *pronator pedis* (Fig. 10). And there is a similar arrangement in the fore limb.

In higher animals the proximal skeletal parts move less upon one another; and the *flexor profundus* grows at the expense of the other components of the deep stratum first mentioned, the germs of which are either absorbed or dwarfed by it, except those of the *interossei.* The *pronator pedis* also in part blends with it, the tarsal portion of its origin forming the *accessorius*[1], and the fibular portion of it forming the *flexor hallucis.* This last joins the deeper surface of the *flexor profundus,* and may be destined, as its name implies, chiefly

[1] In Proboscis Monkey the *accessorius* is united with the tibial flexor (*flexor prof.*) only.

The union of the two strata is sometimes (Unau) retained by the blending of the *accessorius* with the *soleus,* and also by a slip in the same animal from the *tibialis posticus* to the *flexor sublimis.* In Orycteropus also the *tib. post.* sends a slip to the *plantar fascia;* and in Unau it sends a slip to the superficial flexor tendon of digit IV.

In Phoca the *tibialis posticus* retains its connection with the elements of the short flexor muscles of digit I.

I have already (footnote on p. 364) mentioned slips from the deep to the superficial flexor of the digits; and, in Phoca, Otter and Racoon, slips pass from the *accessorius* to the superficial flexor tendons or to the *plantaris fascia.*

In the Rabbit the *tibialis posticus* curls over the inner side of the scaphoid bone and terminates in the extensor tendon of digit II., thus contrasting with the termination of the *tibialis anticus* in the *flexor digitorum* which we have marked in Unau, *Journ. Anat.* IV. 66.

to the hallux; or it may form part, and even the greater part, of the tendons to the other toes[1].

The elements of the *pronator manûs* become disposed of in much the same way as those of the *pronator pedis;* but they rarely contribute an '*accessorius*[2]' origin from the carpus, corresponding with the *accessorius* muscle in the foot. They become, however, more closely blended with the *flexor profundus digitorum* above, than do their homologues in the leg; that is to say, the ulnar origin of the *fl. dig.* does not retain its individuality so much as does the fibular origin in the hind limb; and when a *flexor longus pollicis* is segmented it is so from the radial side[3].

In this arrangement of the parts in the fore limb of higher animals we note more deviation than in the hind limb from the primitive simple condition. In the hind limb the pronato-flexor fibres chiefly take an oblique direction, from the fibular side downwards and inwards, and combine the movement of pronation with that of flexion. In the construction of the fore limb provision is made that each of those movements should take place in a greater range and each more independently of the other than the hind limb. For this purpose the muscular fibres are arranged into two more distinct sets, a pronator set passing to the radius and a flexor set passing to the digits; and the latter take a more vertical

[1] It is not an uncommon arrangement, in Monkeys especially, for the tibial flexor to pass chiefly to digits III. and IV., the fibular flexor passing chiefly to the other digits; and the *lumbricales* then commonly arise from both. In Proboscis Monkey the *fl. tib.* passes to digits II. and V., and the *fibularis* to I., III., and IV.; and, which is very unusual, the two muscles are not blended in any part of their course but are quite distinct.

[2] In some Saurians (Scinc) a muscle arises from the cuneiform bone and passes to the deeper surface of the tendon of *fl. d. s.*, representing the *accessorius.*

[3] In the wild Cat the *fl. prof.* is large, dwarfs the *fl. sublimis* and derives origin from the internal condyle, the ulna and the radius; and each of the tendons, traced upwards, acquires fibres from the several origins, the tendon to the pollex acquiring as many fibres from the condyloid and ulnar as from the radial origin. In the Dog the radial portion passes chiefly into the tendon to the pollex, the ulnar portion chiefly into the tendon to digit V., and the condyloid portion chiefly into the other three tendons. It is seldom, however, that the radial portion to the pollex is so completely segmented as in Man.

Such varieties are very significant with reference to the mode of development and the homological relations of muscles. They shew great diversity in the arrangement and blending of corresponding embryological germs without any obvious purpose, a tendency to variety within the range permitted by the high controlling forces which ensure the requisite subservience to utility.

course; indeed, they scarcely shew any indication of crossing from the ulnar towards the radial side.

The deepest part of the *pronator manûs* mass becomes the *pronator quadratus* which, below, may (Scinc) extend upon the carpus and, above, may reach and blend with the *pronator teres.*

The elements of the tarso-metatarsals (or carpo-metacarpals), the metatarso- (or metacarpo-) phalangeals and the phalangeals follow those of the pronator pedis (or manûs) in uniting with, or retaining their union with, the *flexor profundus.* Advancing forwards, however, they often separate from it, and, attaching themselves to the sides of the phalanges, form the *lumbricales* from their lateral parts and the *retinacula* from their middle parts. The phalangeals are probably included in the latter, but occasionally remain separate and often disappear. Hence the *lumbricales* are commonly found chiefly upon the deep surface of the angles between the tendons of *flex prof.*, and are often nearly or quite continuous with the *accessorius.* In the cases of the lateral digits, I. and V., their elements remain in part or wholly upon the metatarsals and form the short flexors. For this reason the *lumbricales* are not usually present on the tendons to these digits, or one only is present, lying upon the tibial (or radial) side of the tendon to digit V. More rarely there is one on the fibular (or ulnar) side of the tendon to digit I[1].

To put it in another way, the *lumbricales* and *retinacula* may be regarded as parts of the common flexor mass, which, instead of becoming segmented into metatarso-phalangeals and phalangeals, retain their connection with the flexor tendons and are separated with them from the tarsus and metatarsus; but they are not detached from the phalanges to which they accordingly pass from the flexor tendons. Their connec-

[1] In some animals (Scinc) the *lumbricales* pass from both sides of the several tendons of the *fl. prof.* to both sides of the digits. In the foot of Pteropus there are eight *lumbricales*—one on the fibular side of the hallux, one on the tibial side of digit V., and one on each side of each of the other digits. Usually, in Mammals, they arise only from the approximated sides of the tendons (or, as commonly described, from the clefts between the tendons); and the fibres, instead of following the two sides of the several tendons and forming eight muscles as in Pteropus, are combined into four (the two in each cleft fusing into one) which pass to the tibial (or radial) side of the four outer digits.

tion with the extensor tendons in Man and some Mammals is a reminder of the blending of antagonistic muscles into a common sheath which we have found, as illustrated by Lepidosiren, to be one of the features of the primitive limb[1].

Not only does the *flexor profundus* thus absorb or retain annexed to it these various elements of the deep stratum of the pronato-flexor mass; it also, in most animals above the Salamanders, retains its connection with the terminal middle portion of each digital division of the superficial stratum, or superficial flexor, so passing on to the terminal phalanx; while the lateral portions of the superficial flexor tendons, disconnecting themselves from the middle terminal portion, stop at a preceding phalanx. In this way the deep flexor comes to perforate the superficial flexor, which splits, allowing it to pass[2].

Here I may observe that the ordinary mode of disposition of tendons passing along the digits is that each tendon approaching a joint divides into three. Of these the lateral parts are attached to the phalanx immediately on the distal side of the joint; and the middle part runs onwards to the next joint, where a similar process is repeated. This is best seen in the digits of Birds and Reptiles where there are more than two phalanges, and is well illustrated in the Plate of the Whale's fin by Prof. Struthers (*Journal Anat.* VI. Pl. VII.). It is seen also, according to the view just given, to be exemplified in the usual arrangement of the tendons of the superficial and deep flexors of the digits; these being regarded, as they may be in each digit, to be segments of one flexor prolongation upon the digit. This flexor prolongation first detaches from its sides the *lumbricales* to the first phalanx, runs on, and in like manner detaches the slips of the *flexor sublimis* to the second phalanx, repeating the same process according to the number of phalanges, and finally reaches the terminal phalanx.

THE SUPINATO-EXTENSOR MASSES.

The division of the superficial stratum of this mass, in each limb, into three sectors is more generally found to be distinct

[1] In Pteropus (*Journ. Anat.* III. 306) the *lumbricales* lie in their whole length along the tendons of the *fl. prof.*; and one of these tendons is, for a space, interrupted by muscular fibres.

[2] This continuation of parts of the deep flexor stratum into a superficial region is of like kind to that which has been just mentioned in the instance of the *flexor carpi radialis* passing from a deep level at the wrist to a superficial level in the forearm.

than in the pronato-flexor masses. In some of the lower animals the three sectors arise from the humerus, or the femur, and are inserted by their deeper fibres into the bones of the middle segment of the limb; while their superficial fibres pass on to the distal segments. Owing, however, as before mentioned, to the convexity of the elbow and knee-joints in this direction, they are more cut off from continuity with the muscles above than are the antagonistic pronato-flexor masses. Indeed, in the hind limb, the connection of the supinato-extensor muscles with the femur is commonly reduced to a single tendon. In ourselves it is lost altogether, and the fibres are all directed from the leg-bones downwards, instead of passing, in part, from the femur to the leg-bones.

Traced downwards the middle sector of the supinato-extensor mass varies but little in either limb. It commonly extends upon the digits, forming the *extensor digitorum sublimis* (*communis*), and sometimes reaches to the terminal phalanges. Not unfrequently it does not pass upon digit I. Sometimes it fails to reach digit V.; and in some instances (Aï, Lizards, and Menobranch) it extends no farther than the metatarsus or metacarpus.

The inner—tibial or radial—sector is, in Batrachians, partly inserted into the tibia or radius, and partly runs on to the inner side of the distal segment. In the fore limb it sometimes (Saurians) reaches no farther than the lower end of the radius. Commonly, in Mammals, a segment only of it is inserted into the inner edge of the radius, constituting the *supinator radii longus*, which may extend to the inner edge of the pollex, or may spread upon the palmar surface of the forearm[1]. Other segments, passing close to the carpus and inserted into the metacarpals, constitute the *extensores carpi radiales* (*longior* and *brevior*)[2]. These divisions do not take place in Birds, where the

[1] This muscle is often so disposed as to afford an example of a muscle belonging to the extensor group acquiring, from its position, a flexor action. It is absent in the Rat, Rabbit, Hedgehog, Mole, some Ruminants and others. In Hippopotamus, as already said (footnote on p. 351), it is very large, its origin extending high on the humerus, in the space, external to the deltoid, which is usually occupied by the *brachialis anticus*; and it acts as a flexor of the forearm.

[2] Where there is only one of these it commonly passes to Met. III. (*Journ. Anat.* IV. 45). The second tendon is inserted into Met. II. The insertion of these radial carpal extensors may reach to Mets. IV. and V. (*Journ. Anat.* III.

entire sector is continued to the carpus; neither do they take place in the corresponding sector (*tibialis anticus*[1]), in the hind limb of Mammals and Birds.

The outer or fibular and ulnar sector—the *peronei* and *extensor carpi ulnaris*—usually pass over the ankle or wrist, and each is inserted into the outer side of the metatarsus or metacarpus. They often detach, in each limb, tendons to the *ext. dig.*, which cross beneath the tendons of that muscle, and run along their outer sides to the terminal phalanges. Sometimes they appear to form a group intermediate between the *ext. sublimis* and the *ext. profundus digitorum*[2]. In the foot a further division not unfrequently takes place. One of the segments

308). In Phoca it is inserted into Mets. I. and II.; this variation having relation to the large size of the pollex in that animal.

[1] In a Dog, however, I found a slip given off from the fibular side of the *tib. ant.* joining a slip from the *ext. prof.* (*brevis*) *dig.* and inserted into Met. II. There was also another slip from the *ext. prof.* inserted into Met. III. In the Pig the *tibialis ant.* is very small; and the *ext. dig.* sends tendons to Mets. II. and III. and to the int. cuneiform as well as upon the digits.

In the Hippopotamus the arrangement is peculiar. The *tib. ant.* has extensive origin from the upper end of the tibia, the capsule of the joint and the patella, nearly encircling the *ext. dig.*, to which it sends a slip. It is inserted into the inner side of the internal cuneiform bone and into Met. II. The *ext. dig. sublimis* (*longus*) arises by a strong tendon from the fore part of the ext. condyle and, after appearing from beneath the superficial part of the *tib. ant.*, divides into a superficial and a deep portion. The former, passing in front of the annular ligament, expands into the tough tissue beneath the skin of the dorsum of the tarsus, and acquires an attachment to the bones on both sides of the tarsus. The deeper portion, passing under the annular ligament, divides into two tendons: one, connected closely with the preceding in the leg, is inserted into the cuneiform bones and Mets. II. and III.; the other divides into four tendons to the terminal phalanges of the four toes. The portions of this muscle which are inserted into the tarsus and metatarsus, passing both above and beneath the annular ligament, are described by Gratiolet as appertaining to the *tibialis ant.*; but they arise from the femoral condyle with the *ext. dig.* The *peroneus brevis* is not inserted into the metatarsus, but divides into two tendons which join the fibular side of the tendons of the *ext. subl.* to digits IV. and V. The deep layer in Hippopotamus consists of an *ext. hallucis*, arising from the fibula, perforating the tarsal insertion of *ext. dig. subl.*, and lost upon the second phalanx of dig. II. (there are three phalanges to this digit): also of an *ext. profundus* (*brevis*) arising from the os calcis and dividing to the four digits. Thus, digit II. has three extensors,—*ext. subl.*, *ext. prof.*, and *ext. hallucis*,—a combination, that is, of the extensors which are usually distributed to digits I. and II.

The *extensor digitorum* in the fore limb sends off a slip corresponding with the superficial part of *ext. dig. pedis*; but it is lost in the tissue beneath the annular ligament instead of passing over it. There is no deep (short) extensor of the digits.

The *extensor carpi radialis* presents a striking resemblance to the metatarsal division of the deep portion of *ext. dig. subl.* of the foot above described. It is large, connected on the one side with the *ext. dig.* and on the other with the *sup. r. l.* It is inserted by a broad tendon into the bases of Mets. III. and IV.

See description of *extensor secundus* and *supinator manûs* in footnote on p. 373.

[2] I have described this group as *extensor secundus digitorum*. *Journ. Anat.*, II. 307.

(the *peroneus tertius*) runs to the dorsal surface of the metatarsus and sends offsets to the *extensor digitorum*, which form the *ext. secundus* group just referred to[1]; while two segments run, one (*peroneus brevis*) behind the malleolus to the outer or fibular side of the tarsus, and the other (*peroneus longus*) is prolonged over the fibular edge of the tarsus, beneath its plantar surface, to the metatarsals, often as far as that of the hallux. The two last-mentioned segments thus acquire a flexor action. The course of the *peroneus longus* from the extensor aspect, over the fibular edge, upon the plantar aspect, to the inner side of the foot is paralleled (as suggested, p. 348) by that of the *internal rectus* of Birds and Saurians[2]. Nothing distinctly answering to this plantar extension of the *peroneus longus* is found in the fore limb. In it the whole of the sector passes upon the dorsal aspect, or the ulnar edge of the carpus or the metacarpus. It does, however, sometimes incline to the palmar aspect[3].

The *abductor minimi digiti* is segmented from the lower end of this sector and constitutes a continuation of it upon the ulnar, or the fibular, side of the distal part of the limb; and, in like manner, the *abductor pollicis* or *hallucis* is a continuation, more or less distinctly segmented, of the radial or the tibial sector upon the pollex or the hallux.

The foregoing observations shew that each of the three sectors of the superficial sheet of the supinato-extensor mass, in either limb, may be imperfectly segmented from the others, and that each may extend upon the digits, or may be, partly or wholly, arrested at a more proximal point of the distal segment of the limb.

[1] The *extensor secundus* is formed by the *peroneus brevis* in Hippopotamus.

[2] In Birds the *peroneus l.* takes a more superficial course. Its origin extends over the *tibialis anticus*, meeting the tibial origin of the *gastrocnemius*; and its tendon forms part of the *flexor sublimis digitorum*, and also joins the sesamoid body through which the tendons of *fl. dig.* pass. In some animals it takes origin from the femur as well as from the fibula.

[3] In Birds the ulnar segment of the *extensor carpi ulnaris*, arising from the back of the ulna and supplied by the radial nerve, is inserted into the metacarpal (IV.) and is so placed as to exert a distantly flexor action, thus resembling the *peroneus brevis*. This is very decided in the Swan and the Kite. In the Hippopotamus the *ext. c. u.*, which is composed chiefly of tendon or fascia with a few muscular fibres, approaches the palmar aspect of the ulnar side of the forearm, and is inserted into the large pisiform bone, with the *flexor carpi ulnaris*, so as to combine with it in flexing the carpus.

See divisions of *ext. c. u.* resembling those of *peroneus*. *Journ. Anat.* IV. 45.

The deep strata of the supinato-extensor masses correspond generally with those of the pronato-flexor masses. They pass from the fibula and the tarsus, or the ulna and the carpus (in the fore limb from the humerus also), inwards and downwards, to the tibial or the radial side of the foot or the hand, and to the digits. They are frequently in some degree blended, above and below, with the several sectors of the superficial stratum.

In the hind limb the most persistent part of the stratum is the lowest part—the *extensor brevis*, or rather *profundus digitorum*—which may arise from the tarsus, or the fibula, or both. Its tendons blend with those of the *extensor sublimis*, passing to their under-surface and margins, or frequently to their outer margins only. When (Aï and Lizards) the *ext. subl.* does not extend upon the digits, the *ext. pr.* takes its place, constituting the chief or sole extensor of the digits. It is in the digits sometimes blended with the *interossei*. It is, not unfrequently, united with the peroneal tendons which passing upon the digits form the *ext. secundus;* or the peroneal sector may supply digit v. to the exclusion of the *ext. prof.*; or that digit may be omitted by both. In Cryptobranch (p. 29, Fig. 15), a small portion of this deep stratum, a small muscle, that is, passing from the fibula, continuous with the *extensor profundus* and inserted into the tibial side of the metatarsus, is a *supinator pedis*, which corresponds with the *supinator manûs*.

In Unau and Aï this portion extends higher and forms part of the *tibialis anticus*[1]. In most Mammals this highest part of the deep supinato-extensor stratum is not implanted with the *tibialis ant.* into the tarsus. It does not, therefore, form a *supinator pedis*, but it runs on to the hallux, forming the *extensor hallucis*, and standing in the place of a division of the *extensor digitorum sublimis.* Thus the hallux derives two tendons from the deep stratum, one from the *ext. dig. prof.*, and one from a higher part of the stratum; instead of, as in the case of the adjacent digits, having one tendon from each stratum.

In the fore limb the disposition is often, in some respects,

[1] *Journ. Anat.*, IV. 66. A lower segmented portion in these animals runs from the extremity of the fibula to the internal cuneiform bone. The still lower segment, arising from the tarsus, forms the *ext. dig. prof.*

different. The upper part of the stratum commonly preponderates over the lower, and often extends up to the outer condyle of the humerus. Passing from this point upon the upper part of the radius it constitutes the *supinator radii brevis*[1]. Lower down, passing from the ulna to the radial edge of the carpus or metacarpus, it forms (Cryptobranch, Fig. 17) the *supinator manûs*, commonly called *ext. ossis met. pollicis*. Lower still, as in the hind limb, it passes in one or two portions upon the pollex, which take the place of a division of the *ext. digit. subl.* Still lower, it may send tendons to digit II. and perhaps to other digits, so forming an *extensor profundus*[2]. These tendons join the outer or ulnar sides of the tendons of the *ext. subl.* Towards the ulnar side of the hand these tendons are usually absent; and their place is sometimes supplied by offsets from the ulnar sector of the superficial stratum above-described, forming an *extensor secundus;* in the same way that the tendons of the *ext. profundus* in the hind limb are sometimes supplanted by offsets (*extensor secundus*) from the peroneal sector[3].

It is evident, in short, that the muscles in the fore limbs of Mammals, which we are in the habit of designating *extensores pollicis, indicis,* &c., are really elements of the *extensor profundus;* and they correspond with the *extensor profundus* of the foot, but take their origin from a higher point of the

[1] This is absent in Rabbit, Pig and some others. It has a sesamoid bone near its origin in Manis.

[2] In Hatteria the muscle is described by Dr Günther (*Phil. Trans.*, 1867, p. 614) as composed of fibres "arising from the distal half of the ulna and spreading over the bones of the carpus to which they are attached: the fibres nearest the radial margin are collected into a tendon which is inserted into the metacarpal bone of the thumb." It is covered by an *extensor communis dig.;* and an extension of it to the phalanges of the digits would have constituted an *extensor profundus* (*brevis*) *dig.* corresponding nearly with the ordinary *ext. pr.* (*br.*) *dig. pedis.*

[3] In the Hippopotamus an *extensor secundus* in the fore limb arises from the ulna and passes to the ulnar sides of the terminal phalanges of digits IV. and V., joining the sides of the tendons of the *ext. subl.* and precisely corresponding with the distribution of the *peroneus brevis* in that animal.

The deep stratum in the Hippopotamus is concentrated into one muscle, the *supinator manûs* (*ext. poll.*) which is small, arises from the ulna, and passes between the *ext. dig.* and the *ext. c. r.*, then, over the latter, to the rudimentary trapezium into which it is inserted. In appearance and position, in its upper part, it resembles what I have described in this animal (footnote, p. 370) as the *ext. hallucis;* but its insertion is different, and it passes over, instead of perforating, the *ext. c. r.* It corresponds precisely with the *supinator pedis* of the Cryptobranch above mentioned.

limb. The uppermost of the group—the *extensor ossis metarcarpi pollicis*—being inserted into the radial side of the carpus, and sometimes of the metacarpus, is better designated *supinator manûs* or *carpi*. It, in conjunction with the true *extensores pollicis* on the one side, and the *extensores carpi radiales* with the *supinatores radii* on the other, constitute the radial sectors, deep and superficial, of the supinato-extensor mass; and they correspond with the tibial sectors of the same mass in the hind limb which is resolved, in different animals, into *extensores hallucis, supinator pedis* or *tarsi* and *tibialis anticus*. The chief difference consists in the freer segmentation of the mass in the fore limb, in accordance with the freer movements of the several parts. Thus in Mammals the *extensores carpi radiales*, the *supinatores radii*, and the *supinator manûs* have their homologous elements, so far as they are developed in the hind limb, all blended in the *tibialis anticus*, from which the *extensor hallucis* is, in some instances, barely segmented. Another difference in the disposition of the stratum in the two limbs of most Mammals consists in the attachment of the fibres of a considerable part of the stratum in the hind limb to the tarsus—the origin, that is, of the *ext. prof.* from the os calcis. A similar disposition is, however, met with in the fore limbs of many Reptiles and in some Mammals[1].

Usually (though not in so primitive a form as that of the Cryptobranch, p. 41) the elements of the deep extensor stratum, like the elements of the deep flexor stratum, are continued upon the phalanges farther than those of the superficial stratum. Thus, as already seen, the superficial extensor in Menobranch, Lizards and Aï stops at the metacarpus. In the Bird's wing it is inserted into the first phalanges[2]. In Mammals the greater part of it is inserted into the second phalanges; whereas the

[1] *Journal of Anatomy*, IV. 47.

[2] In Birds there are commonly only two rows of phalanges in the wing. In the Swan, where there are three rows, the superficial extensor is still inserted into the first row; and the deep extensor, which arises by two portions (a superficial and a deep) from the radius, is chiefly inserted into the second row and sends on a delicate slip to the third. This is the case also with the *interossei*.

In the Bird's foot, on the contrary, the superficial extensor reaches the terminal phalanges; the deep extensor, when present, joins, as in Cryptobranch, the deep surface of the superficial extensor; and the *interossei* are inserted into the proximal phalanges.

elements of the deep stratum arising from the carpus or tarsus, and the radius and ulna, or the tibia and fibula, as well as the elements of the still deeper—the interosseal—stratum, are continued to the distal phalanges.

When factors of the *superficial extensor* are continued onwards with prolongations of the deep stratum to the terminal phalanges, they are usually derived from the marginal parts of its digital tendons, the middle part of each tendon being inserted into the more proximal phalanx. Also when the tendons of the superficial extensor reach to the terminal phalanges, without such prolongations of the deep stratum, it is still their marginal parts that do so. Thus in the lateral or fibular digit of the Swan's foot the extensor tendon passes over the first phalanx without being attached to it. It then divides into three; of which the middle is inserted into the second phalanx, and the two lateral components pass onwards. The tendon resulting from their union is, in like manner, again subdivided; the middle portion being inserted into the third phalanx, and the two lateral portions running onwards and meeting to be inserted into the fourth phalanx.

This disposition is the reverse of that of the antagonistic tendons on the flexor aspect. In their case (as mentioned at p. 368), the deeper and more prolonged tendon occupies the middle position, and continues its course in that position onwards to the terminal phalanx, while the superficial tendon is inserted into one, or commonly both margins of a more proximal phalanx. Also when the superficial and deep flexor are fused into one, and that one subdivides to supply the several phalanges, it is usually the middle part which is the more prolonged; and it never receives any marginal additions from the deeper strata.

The *interossei* in the simple limbs of some of the lower animals, as Cryptobranch, are mere bands passing across between the metacarpals or metatarsals, drawing the digits together and antagonising the abductors of the marginal digits. In higher animals, where the metacarpals and metatarsals admit of very little movement to and from one another, the tranverse direction of the interossei is changed for a course more parallel with the digits; and they extend upon the phalanges and, in many instances, blend with the extensor tendons. Their proper complement, when thus arranged, is one on each side of each digit; and their action, as flexors, extensors, adductors or abductors, depends upon the part of the phalanges or their tendons to which they are attached. The resultant of their combined action, especially in the simple transverse mode of disposition, is to approximate the other digits to the middle one. Practically, however, they are usually so arranged and co-ordinated that they effect lateral inclination of the phalanges in both directions. Those which incline the other digits towards the middle one are commonly situated near to the plantar or the palmar aspect, and are associated in action with the flexor muscles of the digits, even though they may be blended with the extensor tendons; and those which incline the digits from the middle one are situated nearer to the dorsal aspect, and are associated in their action with the extensor muscles. In many animals the lateral inclination of the phalanges is very slight, being limited to slight separation of the digits in extension and approximation during flexion. The *interossei* in them grow towards the palmar or plantar aspect, appear all to be associated with the flexors of the digits, and are sometimes aided by an additional, or second, series developed beneath, i.e. superficial to, them[1].

[1] The *interossei* in the hind limb of the Hippopotamus are one on the plantar surface to each side of each digit. They arise from the heads of the metatarsals and the sheath of the *peroneus l.*, and pass to the sides of the sesamoid bodies and the sides of the first phalanges. In addition to these eight are two, larger and more superficial than the others, arising from the sheath of the *peroneus*, and passing to the apposed sides of digits II. and V., adducting those two to each other strongly. There are no dorsal *interossei*.

In the fore limb the arrangement is the same: viz. the eight small muscles lying close upon the metacarpals and the two larger muscles, adductors of digits II. and V., arising from the middle of the carpus. There are, besides, two abductors of II. and V., the one arising from the scaphoid and the other from the pisiform bone. These are barely represented in the hind limb by small muscles passing from the cuboid and the internal cuneiform bones.

The two adductors in both limbs resemble the palmar *interossei* of Man.

There is in each limb only one *lumbricalis*. It arises from the superficial surface of the *flexor profundus* before the division to the digits, and runs to the preaxial side of the fourth digit.

Fig. 39.

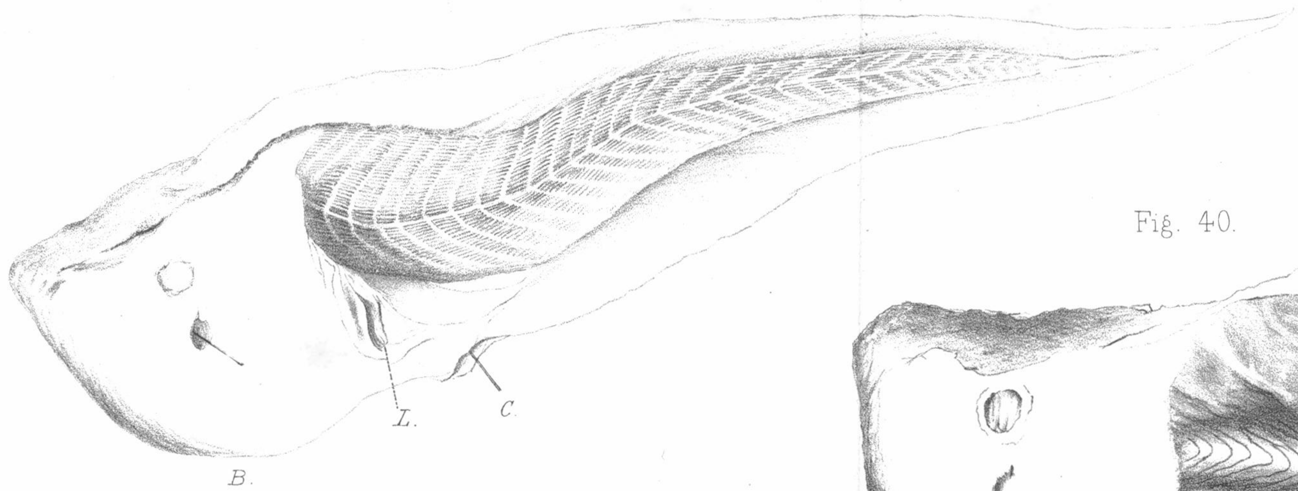


Fig. 40.

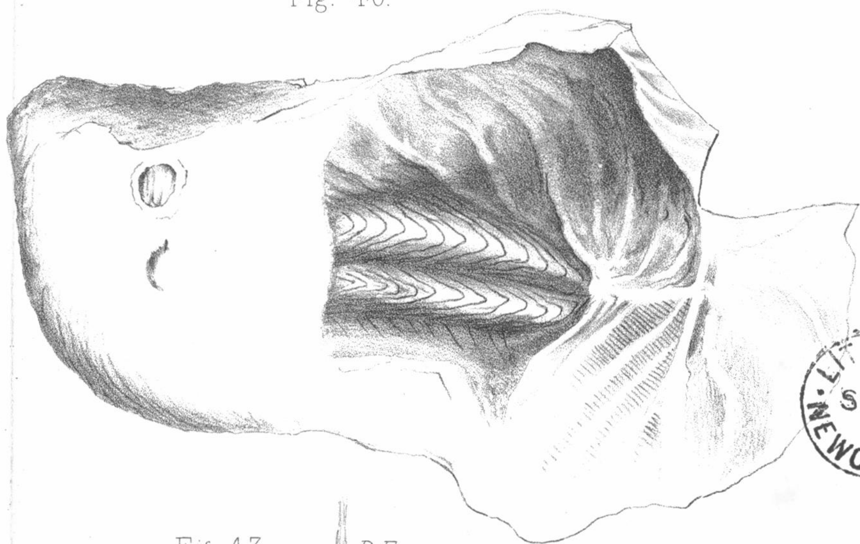


Fig. 41.

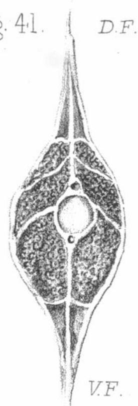


Fig. 42.

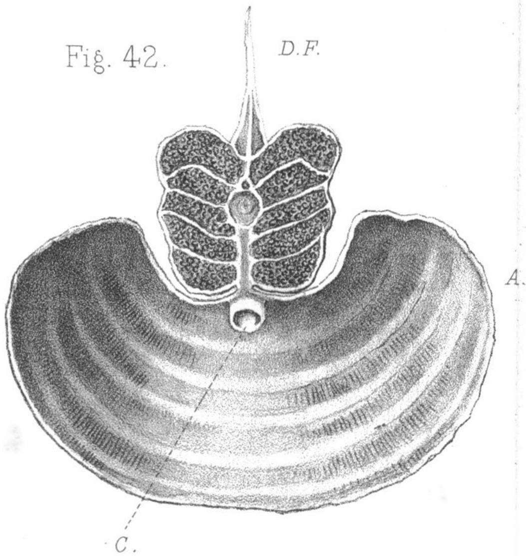
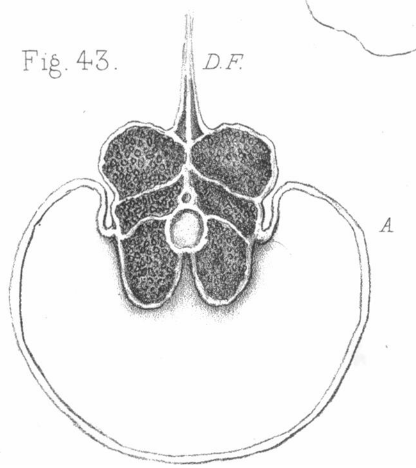


Fig. 43.



Pseudis Tadpole. (p 300)

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Fig. 44.

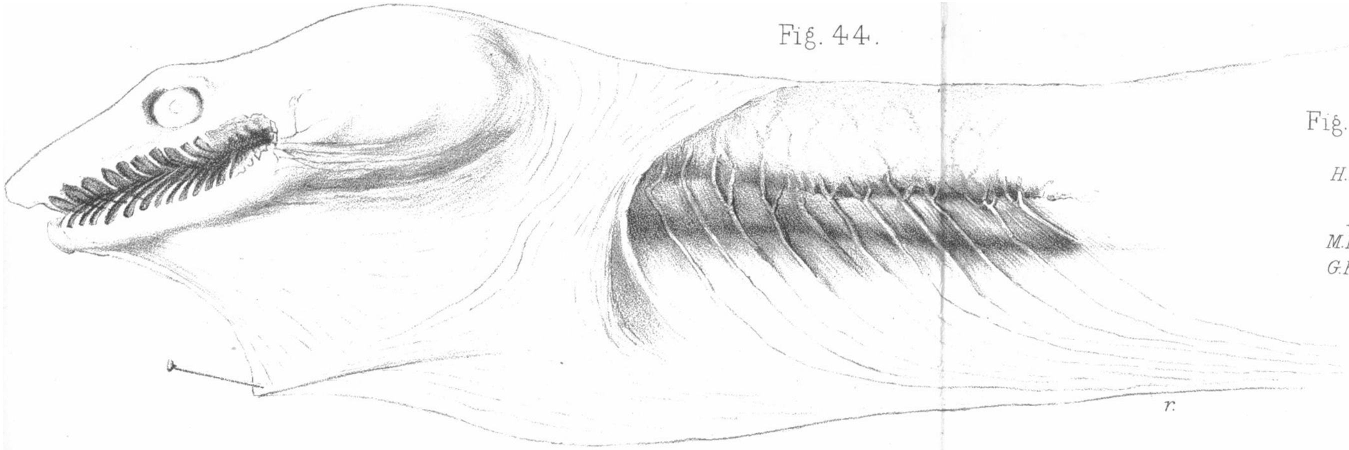


Fig. 45.

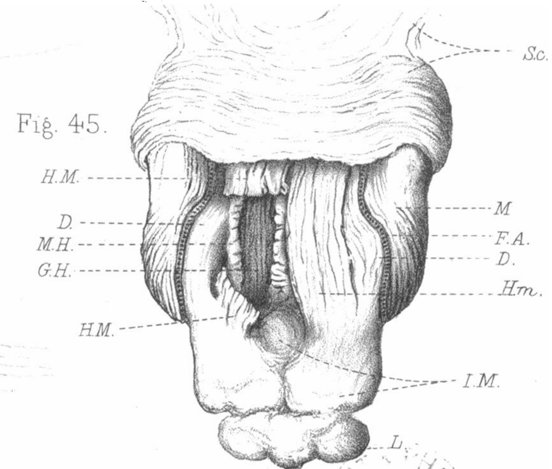


Fig. 46.

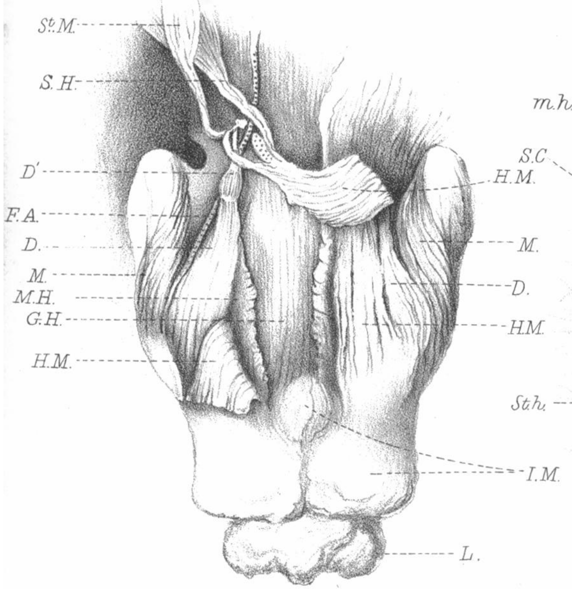


Fig. 47.

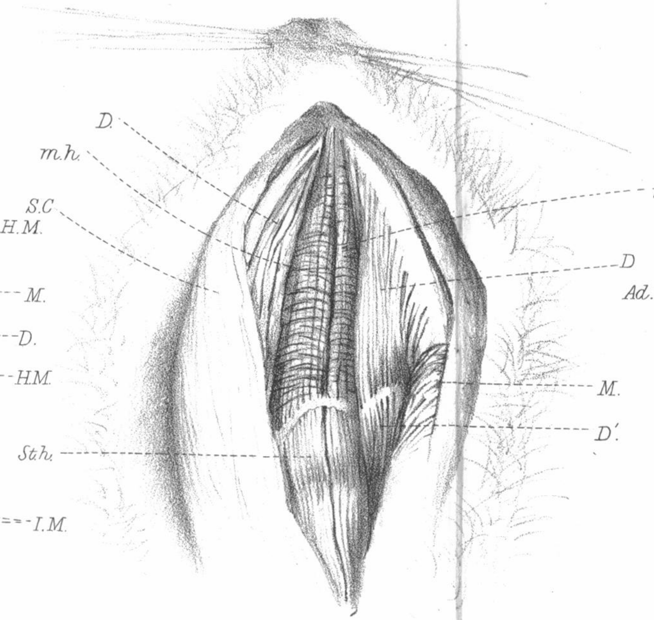
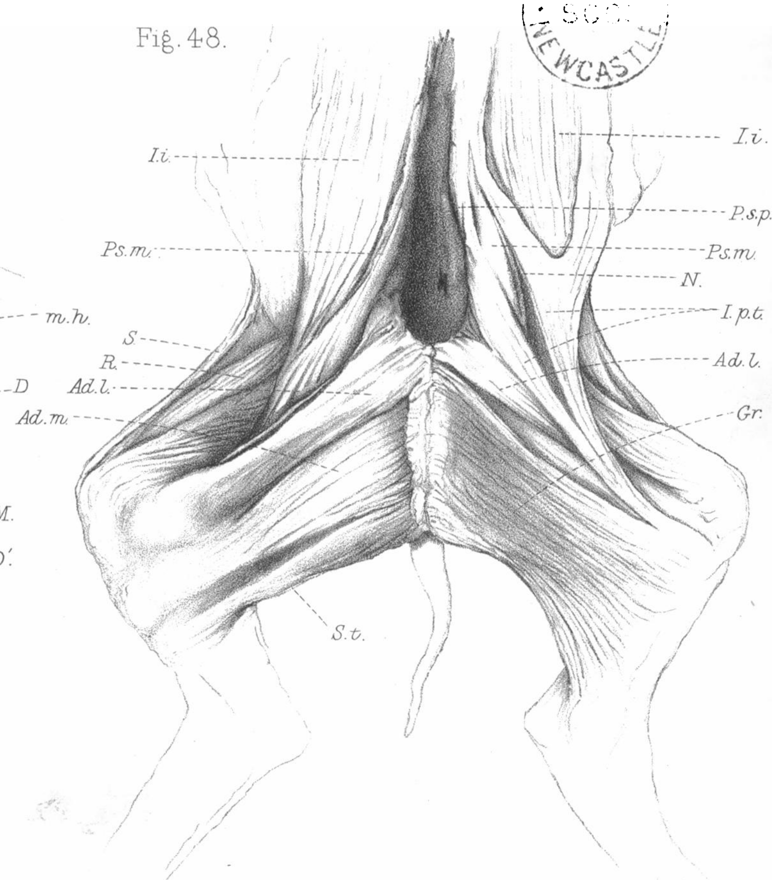


Fig. 48.



Hippopotamus, (p. 325/348) Diamond Snake, (p. 317) Cat, (p. 325.)

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