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ON THE CERVICAL VERTEBRAE AND THEIR ARTICULATIONS IN FIN-WHALES. By JOHN STRUTHERS, M.D., *Professor of Anatomy in the University of Aberdeen.* (Plates I. and II.)

THE great diversity presented by the cervical vertebrae in Whales gives a special interest to this part of Cetacean anatomy. The differences relate chiefly to the amount of ankylosis and the extent to which the transverse processes are developed. These differences have been a good deal relied on in endeavouring to distinguish genera and species, and have been regarded mostly from that point of view. Yet these various conditions of the cervical vertebrae do not follow the natural affinities within the order, nor can we say that the circumstances which determine them are understood. Sufficient allowance has not always been made for difference of age and for individual variation, which the study of a series of specimens from the same species alone can teach us; and these vertebrae have been but little examined in the light of their relation to the soft parts, although without an examination from this point of view it is impossible to interpret the modifications which bones present. The following remarks are founded on the observation of a series of osteological specimens and on the results of the dissection of the soft parts. I shall first consider the neck in Fin-Whales, arranging my remarks in the following order.

1. Fin-Whales examined.

(A) In Great Fin-Whales:

2. Transverse Processes viewed in relation to function.
3. Ligaments of the Transverse Processes.
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18. Bodies and their Fibro-Cartilages.
19. Articulations of the Axis and Atlas.
20. Occipito-Atlantal surfaces.
21. Explanation of the drawings.

1. FIN-WHALES EXAMINED.—The specimens to be considered belong to the following Whales.

(*a*) Great Fin-Whale (Balaenoptera musculus, Ptero-balaena communis, Razorback) stranded alive near Wick, Caithnessshire, June 1869. Male 65 or 66 feet in length. Mature or aged. Soft parts dissected[1].

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[1] I am indebted for information regarding this whale, and for the parts of it, to the kind exertions at Wick of Captain C. Cox, and Dr R. MacCalman, and afterwards, at Golspie, to Dr John Gunn, and Dr Soutar of Golspie. The carcase after being flensed near Wick, drifted south to Golspie. The information kindly furnished me by Dr Soutar and Captain Cox leaves no doubt that it was the same carcase. The total length according to one account was 72 to 73 feet, but Captain Cox's careful measurement, with a tape line, from the tip of the upper jaw straight along to the middle of the hinder edge of the tail, reduced this to 65 or 66 feet. I am indebted to the kindness of that gentleman for the following information. It was alive when stranded, and he saw it an hour after, quite fresh and uninjured. Skin on the under half plaited and white, or just a shade darker than white. The bristly part of the whalebone was white, and the solid part adjoining it had nearly the same colour, becoming slaty and then dark at the outer part. Length along the outside of the solid

(*b*) Great Fin-Whale (B. musculus), November 1871, at Stornoway, Lewis, Western Islands of Scotland. Male 60½ feet in length. Mature or aged[1].

(*c*) Great Fin-Whale (B. musculus), June 1871, at Peterhead, Aberdeenshire. Male 64 feet in length. Not quite mature. Soft parts dissected[2].

(*d*) Atlas and Axis of another Great Fin-Whale (B. musculus), Norway, 1872. Mature[3].

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part of a plate sketched by him for me, 21 inches, of the longest bristles 10 inches, of the shortest 5 inches. Tail-fin 15 feet or more. The lower jaw, now in my possession, is 14 feet 8 inches in length straight, along the outer side 15 feet 10 inches; greatest depth of curve 2 feet; coronoid process high and curved, height along middle 7 to 8 inches, height of bone to tip of coronoid 22 inches. (The upper half of the right coronoid process is fractured, with ligamentous union, the fracture crossing obliquely and breaking off more of the outside than of the inside, with irregular bony surfaces at the fracture. How had this fracture been produced?) The pectoral fin had the usual lance-shape, and was 8 feet 8 inches in length from the head of the humerus. These characters determine this Whale to have been *B. musculus*. As to age, even the distal epiphyses of the radius and ulna are united, an irregular and incomplete furrow ¾ inch from the end marking the place of union. The os magnum and unciform have coalesced on the two surfaces but not deeply, and there is a small trapezoid bone concealed in the cartilage. This Whale was therefore mature or probably aged. The cervical vertebrae are large.

[1] This Whale was found dead about 14 miles off Stornoway, into which it was towed by the fishermen. I am indebted for obtaining the parts to my brother, Dr James Struthers of Leith, and to Mr Methuen of Leith, and for information regarding it to Mr A. Mackenzie and Dr Millar of Stornoway. Their kind attention and replies to my inquiries leave no doubt that it was a characteristic specimen of *B. musculus*. Length according to a public statement 63 feet, according to Mr Mackenzie's measurement, taken along the side, 60 feet 5 inches. Length of pectoral fin 6 feet (taken I infer along the upper border); length of bones of left paddle from head of humerus to tip 7 feet 1½ inches, but tip is malformed apparently from an old injury, somewhat shortening the paddle. Tail-fin from tip to tip 11 feet. Tail part of trunk thin, like a double-edged knife. Dorsal fin falcate and well marked. The usual furrows on the belly and sides. Belly and sides white, with dark patches of cuticle still adhering on the side. Whalebone, longest plates 30 inches; colour dark externally, cream-coloured on the internal bristly surface. Length of lower jaw 15 feet. As to age, all trace of the line of union of the epiphyses has disappeared on the cervical and three anterior dorsal vertebrae, in my possession. The same of both epiphyses of the humerus. The pisiform is partially ossified. This whale was therefore mature, if not aged.

[2] I gave an account of this Whale, and of certain rudimentary structures which I found in it, in this *Journal*, for November 1871. I was indebted to the kind assistance of Dr Jamieson of Peterhead in obtaining the parts of this Whale and for his help when I was engaged on it there. It was a well-marked *B. musculus*. As to age, the epiphyses of the humerus were united, no traces of the line of union remaining. The epiphyses of the vertebrae are united, the traces of the line of union being variously visible on the following vertebrae which I have—on hinder ends of 6th and 7th cervical (slightly also on fore end of 7th) and 1st dorsal; both ends of three succeeding dorsal, of a middle dorsal, and middle lumbar; while all trace has disappeared on an anterior caudal vertebra. Therefore, although longer than the Stornoway one, this Razorback was less mature than it, and the state of the cervical vertebrae agrees with this.

[3] These were among some of the bones of two Great Fin-Whales, brought

(*e*) Lesser Fin-Whale (Balaenoptera rostrata, Pike-Whale) stranded alive at Aberdeen, July 1870. Young female, 14½ feet in length. Soft parts dissected[1].

I shall first consider the great Finners, distinguishing them by their localities (Wick, Stornoway, Peterhead, Norway), noticing afterwards the peculiarities of the young Pike-Whale.

(A) IN GREAT FIN-WHALES.

2. TRANSVERSE PROCESSES IN THE GREAT FINNERS VIEWED IN RELATION TO FUNCTION. The most striking feature in these vertebrae is the enormous mass of the transverse processes, completing a great lateral foramen (see Fig. 4) so large that it is more than half the size of the body of the vertebra, and is twice as capacious as the spinal canal; at once suggesting to the observer that a complete vertebrate segment is entitled to be regarded as presenting not merely two, but four rings. What is the function of these great rings? Contained within them is the *rete mirabile* representing the vertebral artery. This is a vast plexus. To realize the bulk of it, the block of vertebrae now empty should be turned up, the atlas resting on the ground. The series of rings, together with their connecting ligaments, are then seen to form on each side of the vertebral bodies a great lateral canal, like a deep well. This canal is completely filled by the vascular rete, supported by connective tissue and some fat, except the small space occupied by the nerves which traverse it. The canal is continued backwards, diminishing, along the anterior dorsal vertebrae by the rings, or spaces, between the superior transverse processes and the necks of the ribs, or the ligaments representing the ribs. This really wonderful plexus occupying the lateral canal forms communications in various directions, downwards to the carotid region by the

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this year from Aalesund, Norway, for which I was indebted to the kindness of Messrs J. and G. Miller of this city. Although there was no history they are characteristic of B. musculus. Both lower jaws so like each other that they cannot be distinguished. Scapula and radius exactly the size of those of the Peterhead Razorback. Distal epiphysis of radius united, a furrow remaining. The state of the wings of the axis shows it to be more mature than the Peterhead specimen.

[1] This Whale was alive when stranded on our beach. The external characters, measurements, and results of the dissection were noted. The skeleton and various portions of the soft parts are preserved.

passages for the inferior division of the nerves, and also by the sides of the vertebral bodies; upwards, by the passages for the superior division of the nerves; and inwards by the intervertebral foramina, with the primary nerves, giving continuity with the rete within the spinal canal. The spinal canal and its lateral openings, the intervertebral foramina, are much more occupied by vascular rete, with its supporting connective tissue and some fat, than by spinal cord and nerves. While the spinal canal averages 6 to 7 inches in width by about 3 in height, I found in the Peterhead Razorback the tube of dura mater to have a diameter at the fore part of the atlas of about two inches, at the hinder edge of the atlas of about 1½, and at the middle of the neck of about one inch. The rete fills the whole of the rest of the spinal canal, and is therefore many times bulkier than the spinal cord and its membranes. But great as this spinal canal rete is, it is small compared with the rete of each lateral canal. The intervertebral foramina, large enough to admit three or four fingers, are in like manner chiefly occupied by the rich communications between the two lateral and the spinal vascular networks. The nerves are comparatively small, the inferior division about the size of the little finger, the superior several times smaller. Having escaped by the intervertebral foramina, the nerves divide, the superior or dorsal divisions pass immediately up to the dorsal spaces; the inferior or ventral divisions sweep outwards across the upper part of the lateral canal, surrounded by rete, as far as I could decide after it had been removed, and curving downwards a little, escape by the ventral spaces.

Although the protection of this wonderful network may seem a function sufficient to account for the presence of these great rings, this view may be as far from satisfactory as it would be now to regard the double transverse process in man as a provision for the protection of the vertebral artery. In either case the interpretation must be sought not in the idea of a protecting ring, but primarily in the locomotive system, in that of outstanding processes furnishing points of attachment for the muscles and ligaments, the spaces within which are, secondarily, more or less occupied by parts of the vascular system.

The study of the relation of these processes to the soft parts in great Fin-Whales has satisfied me that both upper and lower transverse processes, in their various degrees of development, may be interpreted by dividing them into three stages. (See Fig. 4, also Figs. 1, 2 and 3.) *Lower transverse processes.* (*a*) First or *root stage,* short, directed outwards and downwards, alone present in some. Thick, smooth before and behind. Portions of rete mirabile lie here. (*b*) Second or *tubercular stage.* Directed outwards, extensive, being opposite the inner half or more of the ring; begins by an internal angular protuberance or process, and terminates by an external protuberance; thinner at the upper edge where it bounds the ring, thick and rough below. Besides muscles, this stage attaches a series of strong intertransverse ligaments. (*c*) Third, or *nerve-groove stage,* corresponding to the space left for the passage of the inferior division of the spinal nerve, accompanied by communication of rete mirabile. Process at this stage turns upwards and outwards; groove is on anterior surface, directed obliquely downwards and outwards, broad enough to receive the hand laid flat. The very different thickness of these two stages at their lower part gives, especially where they meet, the twisted appearance which the processes present on their anterior surface.

Upper Transverse Processes. (*a*) First, or *nerve-groove stage,* corresponding to the space for the passage of the upper division of the spinal nerve, accompanied by dorsal communication of rete mirabile. Is opposite the inner third of the ring, reaching from the articular process for three or four inches outwards, broad enough to receive the hand flat. Groove most marked on the posterior surface of the anterior vertebrae and on the anterior surface of the posterior vertebrae. (*b*) Second or *tubercular stage,* opposite the outer two-thirds of the ring; beginning by a marked rough projection on the superior edge, and continuing rough outwards. It attaches a series of superior intertransverse ligaments. (*c*) Third, or *terminal stage;* situated to the outer side of the ring, and curving downwards and inwards a little to unite with the inferior process. It forms the extreme part of the transverse process, is scarcely broader than the processes in adolescence, but in maturity forms a tabular expansion beyond the foramen.

These characters will be recognised if one set of these vertebrae be piled in their natural relation on the table and another set arranged on the floor. Then if the observer, bearing in mind the relation of the human transverse processes to their soft parts, will take an articulated set of human cervical vertebrae and also a separate human cervical vertebra, and compare them in detail with those of the Rorqual, he will recognise an interesting correspondence to the stages above defined, small as the foramen is in man compared with the magnificent rings in the Rorqual. The *anterior process* presents first the root, springing from the body, next the "anterior tubercle," and then comes the groove for the anterior division of the nerve. The successional and functional correspondence is evident though the proportions are different. So also with the *posterior process.* Springing from the pedicle there is, first, a stage across which the posterior division of the spinal nerve passes, corresponding to the nerve-groove stage in the Rorqual; and beyond it the "posterior tubercle," greatly extended in the Rorqual and expanded at the end in the terminal plate.

3. LIGAMENTS OF THE TRANSVERSE PROCESSES.—These processes are very strongly knit together by three series of ligaments. (*a*) Inferior series, uniting the inferior processes; and (*b*) those uniting the superior processes, divisible into superior portion above the rings, and external portion between the parts external to the rings. These are interrupted, or interosseous, ligaments, not longitudinally continuous, although those above and below, especially the latter, are seen on the surface.

(*a*) *Inferior Inter-transverse Ligaments*[1] (Inter-parapophysial) pass between the tubercular stages of the processes. A series of strong ligaments, broader than and as thick as the hand, increasing in breadth forwards and outwards, as the tubercular stages on the bones are seen to do, from the sixth vertebra to the third; from about 5 inches broad on the fifth vertebra to 8 inches broad on the third. They pass between the lower parts of the processes, which are correspondingly rough, while the upper part of the processes is smooth. Between the third and the axis the ligament is larger and

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[1] The parts to which these ligaments are attached are seen in Figs. 1 and 2.

changes its direction, passing very obliquely inwards and forwards to the process and body of the axis; forming a great mass of ligament, 8 inches broad and 1 inch thick. The attachments of this great sloping ligament account for the breadth and prominence of especially the outer part of the tubercular stage of the 3rd vertebra, and for the roughness on the inferior process of the axis opposite the foramen (tubercular stage, but not defined as on the vertebrae behind) and inwards to where it joins the body.

On either side of this series of ligaments spaces are left. The *internal spaces,* between the ligaments and the bodies of the vertebrae, opposite the root stages of the processes, admitting one or two fingers, but in the putrid state easily enlarged as the ligament is thinner here. The rete is seen bulging against this thinner part, and, as far as one could judge after the external parts had been cleared away, appears to have sent communications through the passages. The external spaces are the *nerve-passages,* corresponding to the third stage of the processes. They are about 3 inches in breadth and about an inch longitudinally, diminishing outwards as the processes converge, easily admitting three or four fingers flat. The one between the axis and third vertebra is smaller than the others (2½ inches). Their inner boundary is some way internal to the outer part of the tubercular stage, owing to the obliquity of the groove and the position of the ligaments. Their outer boundary, formed by the lowest part of the ligaments which connect the external part of the processes, is about an inch internal to the outer end of the foramina. Besides the nerve, which is not larger than the little finger, they are occupied by communications of the rete.

(*b*) *Superior Inter-transverse Ligaments and Nerve-spaces.* The dorsal nerve-spaces are between the ligaments externally and the zygomal processes and their ligaments internally. Between the 6th and 7th vertebrae their breadth is 2½ inches, increasing forwards to a breadth of 4 inches between the third and the axis; but the spaces of the posterior are wider. The spaces have a compressed triangular form, tapering outwards, and admit four fingers easily. Besides the nerves, which are small in proportion to the passages (though the disproportion is not so great as, for instance, in the posterior foramina of the human sacrum), they are occupied by rete, sending communications through here, as far as one could judge after the external parts were cleaned away. The superior inter-transverse ligaments (inter-diapophysial) may be conveniently divided into superior and external portions. The *superior inter-transverse ligaments,* commencing a hand's breadth from the zygomal processes, occupy the processes opposite the outer $\frac{2}{3}$ of the ring (tubercular stage). They are attached to about the upper half of the processes, which is rough accordingly, and bevelled so as to turn this part of the surface upwards. Where they commence, at the outer end of the nerve-spaces, is well marked on the bones[1]. The bundles as seen on the dorsal surface are both longitudinal and oblique, while the deeper fibres, more interosseous in position, are oblique. The *external inter-transverse ligaments* are continuous with the last, corresponding to the fact that the outer part of the transverse processes is a continuation of the upper process. They are the strongest ligaments of the processes, and so placed in between the processes, here very close together, that it is only after their division that their extent and attachments can be distinctly made out. Stated generally, these enormous ligaments occupy about the upper and outer half of the breadth of the more or less expanded part of the processes external to the rings, but coming down far enough to form the outer boundary of the ventral nerve-passages, the inner half being occupied by loose connective tissue lying on the reticular periosteum. Corresponding rough and smoother parts are seen on the surfaces of the bones. Between the 7th and 6th processes I found a synovial cavity, in both of the great Finners dissected, nearly two inches in diameter, situated on the lower part of the plate, presenting a periosteal surface on the convex 7th process and a reticular fibrous or cushioned surface on the concave 6th process, surrounded by a capsular ligament. The 6th and 5th were very close, but there was no cavity proper between them (or between any of the other transverse processes). The ligament attached to the upper,

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[1] A smaller and variable rough mark is seen about the middle of the upper edge of the nerve-groove stage on the three posterior vertebrae. It happens to be strongly developed on the left side in the vertebra represented in Fig. 4.

outer, and under parts of the plates was 1 to 1½ inch thick, and about the same between the 5th and 4th, and between the 4th and 3rd.

The ligaments attached to the hinder surface of the great wing-like transverse process of the axis are of enormous strength. It is not very easy to separate any of these vertebrae, but to separate the axis and third is a matter both of art and strength. With a forcible sawing motion the long slicing knife, with barely room to work, at length makes its way through the dense mass. Besides the ligament from the third, the axis has an external compound ligamentous mass from the converged tips of the 4th, 5th, and 6th processes. (1) That from the third passes downwards and outwards to be attached to the wing of the axis. Taking it and the dorsal interosseous ligament as one, the attachment to the axis is over an extent of 12 inches in breadth by two in thickness, following the curve of the process of the 3rd, its position on the axis being external to the middle of the broad plate and along the superior process above the outer half of the ring. The deeper part of this ligament is disposed differently, its much longer fibres converging forwards and inwards to near the ring of the axis; thus lining this part of the lateral canal, which receives a funnel shape here from the comparatively small size of the ring of the axis, while the two parts of the ligament receive different obliquities. (2) The external ligamentous mass is a compound ligament proceeding from the converged tips of the four vertebrae behind the axis outwards and forwards to be attached, for about five inches, to the most external and inferior part of the wing. This is the part of the great wing which forms the extreme triangular projection, beyond the rest of the outer edge of the wing.

Whatever may be the meaning of this convergence of the transverse processes in the Rorquals, we see not only that the bones converge here, forming the apex of the pyramidal framework, but that the plates in which they terminate, and by which they come almost in contact, are firmly tied together by these strong ligaments. Viewing the ligaments of the transverse processes as a whole, while, locally, they enable the processes to strengthen each other as parts for muscular resistance, the firm binding together of the whole must co-operate with the firm binding of the bodies in giving strength to the unankylosed neck. The convergence must impede especially lateral motion, and the ligaments between the converged plates must act not merely as binders but as interposed cushions. Viewed in relation to the contents of the canal, if this can be considered a function, the ligaments complete the walls of the canal all round, except at the dorsal and ventral nerve-passages.

I regret that the circumstances were such as to prevent me examining the muscles attached to these processes. The neck having been roughly cleaned, I could only recognise the remains of various strong tendons. One can hardly doubt that the primary function of these processes is to furnish points for muscular attachment, the more essential parts being the superior processes and the tubercular stage of the inferior, while their ligamentous, and especially their nerve and blood-vessel relations, are subsequent. We must look to the muscles for an explanation of the thick single transverse process of the atlas; of the vast and strong-rooted wing of the axis, and its backward slope; to the muscles, and perhaps to the mode of attachment of the first rib, for an explanation of the absence of a bony inferior transverse process to the 7th vertebra; and to the adaptation of the processes which support the anterior ribs, for an explanation of the size and forward slope of the superior transverse process of the 7th vertebra. Between these two great converging and dominating processes, the 2nd and 7th, the outer parts of the intervening transverse processes are packed as best they may in the available space; the 5th is level and the most projecting, the 6th must slope forwards, the 3rd and 4th must slope backwards, while their inner parts are adapted to muscular attachments. If the part where the nerve crosses is ossified, then a ring results. The processes are joined by strong ligaments, giving the various functional results above indicated; and in the space thus left by the adaptations to the locomotive functions, part of the vascular system has been enclosed or has been developed.

4. Ligaments of the Spines, Laminae, and Articular Processes.—In the specimen (Peterhead) in which cervical spinous processes are present, there was a *supra-spinous* ligament; and in between the spines pretty strong *inter-spinous* ligaments,

about half an inch in thickness. The laminae are connected on both aspects by *inter-laminar* ligaments. As seen on the dorsal aspect, the ligament passes from the hinder edge (the thick and overlapping edge) of the lamina to the dorsal surface of the lamina behind. From within the canal a thinner ligament is seen passing from the anterior edge of the lamina forwards to the inner surface of the lamina in front. The fibres of the two seem continuous. The latter corresponds in attachment to the ligamentum subflavum of man, but it is white. Also within the canal there was, at least between the axis and 3rd (the only two vertebrae which had not then been separated), a strap-like interlaminar ligament, $\frac{3}{4}$ inch broad and $\frac{1}{8}$ inch thick, separated from its fellow by a distance of an inch. *Inter-zygomal* ligaments continuous internally with the interlaminar ligaments pass from process to process, covering the processes, and external to them form a considerable longitudinal ligament.

5. ARTICULATIONS BETWEEN THE BODIES OF THE VERTEBRAE.—The inferior and superior common ligaments of the bodies are each about an inch in breadth, and therefore not great ligaments for such bodies. The corresponding marks on the bones are well seen above within the canal, while below there is rather a narrow ridge not running the whole length of the body. There is not much difference in the *fibro-cartilages* between the different cervical vertebrae, though they may diminish a little forwards. Their apparent thickness (length) on the surface is deceptive owing to the bevelling of the edges of the vertebrae, this being exaggerated at the middle line where the bevelling goes so far as to form a notch. This median notch is sometimes nearly filled up by ossification. It is strongly marked on the hinder edge of the axis, while the rest of this edge is less bevelled than the edges of the other vertebrae. The thickness of the fibro-cartilages on the surface is $1\frac{1}{4}$ inch, the real thickness deeply between the bones is less than half this, being about $\frac{1}{2}$ inch; perhaps slightly less between the 4th and 3rd, and $\frac{1}{8}$ inch less between the 3rd and axis.

On section, the fibro-cartilages are seen to correspond very closely in all the spaces, except between the 3rd and axis, where there is a little more of the ligamentous and less of the pulpy part. With a body-surface averaging 12 inches in breadth and

8 in height, the ligamentous or capsular part has an average depth of 1½ inch, dipping in to a depth of 2 inches at the middle line above and below, giving the pulp cavity a slightly figure of 8 form. The print of this attachment is well seen on the bones, with parallel lines marking the attachment of the concentric capsular ligaments. The pulp cavity averages 9 inches in breadth, 4 to 5 in height. An interesting transition is seen from the fibrous to the pulpy, in the form of a floating wedge, projecting ¼ to ¾ inch into the pulp from the fibrous part, and ending in fringes which grade into a tenacious pulp. The bodies where they form the walls of the pulp-cavity are lined by a thin layer of pearly cartilage; the anterior surface of the vertebra slightly convex, the posterior slightly concave. The pulp itself is white and glairy, in some parts tenacious enough to lift with the fingers. It had in part an oily appearance, like soft blubber. Under the microscope it showed chiefly groups of cartilage cells of various sizes, bundles of wavy connective tissue, some free oil-globules, fatty crystals, and crystals resembling those of phosphates, all immersed in a fluid glutinous medium.

The proportion of the fibrous part to the pulpy part, though quite mammalian in contrast with the proportions in the fish, is much less than in man, and still less than in long-necked quadrupeds; but a circular ligament in reality over 30 inches in length and 1½ in breadth is a structure capable of great resistance. The *amount of motion* permitted between the cervical vertebrae, either at the bodies or transverse processes, before the fibro-cartilages have become softened by putrefaction is very limited. The transverse processes may be made to move a little on each other, giving a slight rotatory motion of the vertebrae, and the bodies may be moved on each other a little in any direction. Lateral motion is the least, as it is at once arrested by the transverse processes coming in contact; rotatory motion comes next, and vertical motion is the greatest, but is very little. With the block of the five middle vertebrae still attached (including therefore the united motion of four fibro-cartilages), I could give one end of the block a range of only ¾ inch of vertical motion. It is then firmly and softly checked. On then slicing through the connections between the transverse processes, there was no increase in the extent of the motions at the fibro-cartilages, except a very little in the lateral direction. Although, therefore, the intertransverse ligaments must greatly assist to strengthen the neck, they do not limit the extent of movement at the bodies. Viewing the vertebrae of the Fin-whale's neck as a whole, one could scarcely conceive of any parts more thoroughly bound together than they are, both at the bodies and the transverse processes, into a great fibro-osseous unyielding lump. What then is the functional adaptation? It cannot be strength, as the vertebrae in the ankylosed neck are still more firmly united. When vertebrae are separate a strong binding medium is, of course, rendered necessary, but it would appear that the primary functional adaptation is in the soft cushioning, and that there must be some difference in the actions of the head in the Finners, as compared with the Right-whales, to account for ankylosis not taking place[1].

6. ARTICULATIONS BETWEEN THE AXIS, ATLAS, AND OCCIPITAL BONE.—Besides the ligaments between the spines above, and the continuation of the inferior common ligament of the bodies below, there are strong capsular ligaments enclosing the articular surfaces, and certain internal or central ligaments. The *capsular ligament between the atlas and occiput* (condylo-capsular) are strong ligaments, about $\frac{1}{4}$ inch in thickness, entirely surrounding each articular surface. Coming in contact in the middle, they form a septum between the two joints, where a median groove marking their attachment is seen on the atlas from its canal to its lower edge. This septum has a corresponding attachment on the occipital bone, between the lower ends of the occipital condyles, with corresponding mark on the bones, which but for this would here run into each other. The septum was imperfect and stringy, but this

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[1] Ankylosis had taken place between the bodies of two of the vertebrae, the 3rd and 4th, in the Stornoway specimen, all the other vertebrae in these Fin-whales being free. The ankylosis had been broken up by force before they reached me. A plate of the 3rd had torn off, remaining with the 4th, and exposing the spongy tissue of the 3rd. The ankylosis occupies less than the middle half of the body-surfaces, about 5 inches across and $3\frac{1}{2}$ high, being the central parts of the pulp surfaces. The impression at the attachment of the fibrous part of the fibro-cartilage, and other markings on the unankylosed part of the surfaces, are as usual. Notwithstanding the ankylosis, the articular surfaces between the articular processes of these two vertebrae are not only as well but better marked than those between the 4th and 5th.

may have been from the giving way of parts. In all of the four atlases this median groove is well marked, of varying breadth widening below into a triangular space into which the inferior common ligament dips. The *articular surfaces between the atlas and axis*, on the contrary, run into each other inferiorly, forming one great horse-shoe articular surface on both vertebrae, more or less notched at the middle line inferiorly[1]. The cartilage on the articular surface of the front of the axis, and on both aspects of the atlas, was about $\frac{1}{8}$ inch in thickness. In the Peterhead specimen, and there was an appearance of the same in the Wick specimen, the cartilage along the rim of the cups of the atlas assumed a fibrous appearance, and gave off fringes, half an inch to an inch in length, like a fringed marginal fibro-cartilage, the cartilaginous surface being again smooth for half an inch to an inch beyond the margin, until the attachment of the capsular ligament was reached.

The central ligaments, made out with considerable difficulty, are—(*a*) The transverse ligament of the atlas; (*b*) pair of check ligaments, interosseous between axis and atlas, and two longitudinal ligaments; (*c*) an inferior, the ligamentum suspensorium dentis; and (*d*) a superior, a prolongation of the superior common ligament of the bodies.

(*a*) *Transverse Ligament* (see Fig. 5). This great ligament is attached as in man, but has no contact with the odontoid process, and is flattened in the opposite direction. It divides the canal into two parts, the upper and larger part for the spinal canal, while the lower, narrower and pointed inferiorly, is occupied by ligaments. This explains the peculiar form of the canal of the atlas, the most constricted part corresponding

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[1] In the Wick specimen, however, there is an appearance (see Fig. 5) of a median separation, by a narrow furrow in the lower part, continued along the upper half as a slight irregular depression, still less marked on the axis. In dissecting this joint, as the cartilage had begun to peel off, I could not be certain that it was continuous across the middle line. In the atlas of a fifth great Finner in my possession (afterwards referred to), a larger one than any of the others, and presenting a very wide median groove between the anterior articulating surfaces, there is no trace of median separation of the two joints on the posterior surface. In the axis of a fifth (young) great Finner (afterwards referred to) the horse-shoe surface appears as if divided by a faint median elevation. These appearances I believe to be deceptive, not implying that the cartilage and synovial membrane were not continued across in these as in the other specimens.

to where the attachment of the ligament begins superiorly. It is a thick flat ligament, measuring when fresh 2 to 2½ inches from border to border, half an inch to an inch in thickness, as thick and nearly as broad as three fingers laid flat; its breadth is about 2½ inches, corresponding to the width of this part of the foramen. Its upper border is concave, bounding the spinal canal, its lower border bounding the canal through which the suspensory ligament passes. Its attachment to the atlas is as far back as possible on the wall of the canal, but there is still left a space between it and the odontoid large enough to admit the fingers flat, though its upper edge comes close to the summit of the odontoid process, when, as in the Peterhead specimen, that process is better marked. It is composed of dense transversely arranged fibres, passes straight across, and is a tight strong resisting structure. Functionally viewed, this ligament is here adapted to serve as a great fibrous beam, presenting its posterior surface as a continuation of the area for the attachment of the check ligaments, while its edges afford attachment to part of the longitudinal ligaments.

(*b*) *Check Ligaments* (Alto-odontoid). This pair of ligaments forms the chief retaining structure between the axis and atlas; attached behind to the side of the odontoid area, in front to the crescentic depression on the atlas internal to its articular surface. An examination of the bony surfaces will enable their attachments to be readily understood. On the axis, bounded by the articular surfaces at the sides and below, and by the spinal canal above, is a large non-articular area, from 5 to 6 inches across and about 4 inches vertically. The whole of this area forms a gentle elevation, rising below the middle into a low conical eminence. While the whole may be termed odontoid area, the latter may be distinguished as the odontoid process. The summit of the process is situated at the junction of the lower and middle thirds of the area. To this process, and to the rough slope below it, is attached the ligamentum suspensorium; while, laterally, along the base of the process and the side of the area, is attached this great check ligament, the convexity of its semilunar attachment not going to the outer part of the area, and its horns approaching those of its fellow above and below. On the posterior aspect of the atlas the attachment is well marked, as a depressed crescentic surface between the articular surface and the edge of the canal (see Fig. 5), varying from 1 to 1½ inch in breadth, tapering upwards and downwards. The check ligament, itself crescentic in section, is attached to this rough crescentic surface; its lower part converges to join its fellow at the middle line below the canal, and is attached also to the neighbouring part of the wall of the canal; its upper part reaches inwards upon the transverse ligament, to which it has a true and extensive attachment. The check ligament is over 3 inches in height, its greatest thickness about 1½ inch. The fibres are longitudinal, direction forwards and a little outwards, length half an inch to an inch. The shortness, size, and interosseous position of this great ligament, explain why the motions between the atlas and axis are so very limited. The dissection of these check ligaments in the great Finners is very difficult. When the atlas is separated forcibly from the axis, they tear off from the axis, leaving the odontoid area bare and a few tufts attached to the process; and the lower part of the canal of the atlas is seen to be blocked by a dense pre-odontoid fibrous mass, below the middle of which is a conical recess into which the tip of the odontoid had sunk, the recess being now the hollow base of the suspensory ligament.

(*c*) *Ligamentum suspensorium dentis* (Occipito-odontoid). This ligament, about the size of a thumb, arises from the tip and lower slope of the odontoid, passes through the aperture below the transverse ligament, shows itself free for about 3 inches between the atlas and occiput, is here compressed laterally (vertically 1 inch, transversely $\frac{4}{8}$ to $\frac{5}{8}$ inch), and passes forwards to be inserted into the triangular fossa between the occipital condyles. The appearance of the lower part of this ligament being attached to the atlas, on its way forward, is due to its fibres being continuous with those of the check ligaments where they meet in the middle line below. There is the appearance as if it afterwards received an accession of fibres at the sides from the atlas and above from the lower edge of the transverse ligament, but this is not easily determined as its circumference is not isolated as it passes through the aperture below the transverse ligament. The occipital condyles are for about 5 inches separated only by a deep narrow fissure, attaching the septum formed by the condylo-capsular ligaments, and above this they diverge upwards, leaving a triangular fossa 3 inches in length, $\frac{3}{4}$ inch deep, and $1\frac{1}{2}$ to 2 inches wide at the base where it is bounded by the foramen magnum. In this triangular fossa the suspensory ligament and the superior longitudinal ligament have a continuous insertion.

(*d*) The *Superior longitudinal ligament* (Occipito-axoid), a prolongation of the superior common ligament of the bodies of the vertebrae, a pretty strong flat ligament, passes from the upper surface of the body of the axis forward, partly joining the upper part of the transverse ligament but mainly continued on above that ligament, and now expanding passes to be inserted into the intercondyloid fossa with the suspensory ligament, to which it has previously adhered. Tracing these two ligaments backwards, they are separated by the vertically extended transverse ligament, to the edges of which they partly adhere, the lower passing to the odontoid, while the upper passes to the axis proper. The soft parts which occupy the middle line between the occipito-atlantal joints are the following, from the lower edge of the body of the atlas up to the spinal canal. 1, Median septum for 5 inches, formed by the close-together condylo-capsular ligaments. 2, Ligamentum suspensorium. 3, Mass of rete mirabile, in the triangular space between this and the next ligament and between the now diverging capsular ligaments on each side, giving this part a bulky appearance. 4, Superior longitudinal ligament.

Viewing these ligaments homologically and functionally, the transverse ligament is recognised, fully developed, and adapted to assist in binding the axis to the atlas by the attachment which it affords to other ligaments; the superior longitudinal ligament is as in man, and partly adheres, as it also does in man, to the transverse ligament; the inferior longitudinal ligament is a true ligamentum suspensorium dentis, connecting the odontoid and occipital centra; the check ligaments correspond to the lower check ligaments of man greatly developed; while the upper, or occipito-odontoid, check ligaments are suppressed, or converged and united with the suspensory ligament.

THE CERVICAL VERTEBRAE SERIALLY CONSIDERED.

I have examined these vertebrae closely with the view on the one hand of determining their more essential characters, and on the other hand of observing the differences which they present according to age or individual variation. The series of specimens were compared when arranged in position, as seen in Figs. 1, 2 and 3, and when arranged separately, and it will be observed when the remarks refer to them specially when in position and when separate. It is to be borne in mind that of the three whales to which these observations chiefly refer, the Peterhead one was scarcely mature, the other two being mature or aged. From the much greater size of its vertebrae the Wick whale might have been supposed to have been a much larger animal, but its length was only one or two feet greater than that of the Peterhead whale (65 to 66 against 64), while the mature Stornoway whale was only 61½ feet. Even when the length is ascertained by careful measurement with a tape line, there may be different results. Had I gone by the measurement along the back, the length of the Peterhead whale would have been stated as 68 instead of 64 feet; but the measurement ought always to be straight along the side, giving the length of the ground over which the animal extends. But making due allowance for this source of variation in the statements as to length, no reason appears why full-grown whales of the same species should not vary as well as men, some inches in the one being the equivalent of some feet in the other. Although variation in length in man may depend chiefly on the lower limbs, the enormous elongation of the caudal part of the trunk, the locomotive equivalent, in whales gives ample scope for trunk variation.

7. MEASUREMENTS.—The measurements given in the table were made with care, and may be useful for consultation. They show points of correspondence and variation besides those referred to in the remarks. The transverse measurement of the transverse processes (No. 2) is taken from the middle of the side of the body; taken from the anterior edge of the body would give nearly half an inch less. The length of the spinous pro-

TABLE OF MEASUREMENTS OF VERTEBRAE OF FOUR

	Atlas.				Axis.				3rd.		
	Peterhead.	Stornoway.	Wick.	Norway.	P.	S.	W.	N.	P.	S.	W.
1. Greatest width	26	28	27¼	27	39½	42½	46	42	31¾	36	38
2. Width of transverse processes. R. L.	6½ ,,	7¾ ,,	7 ,,	7 ,,	15 17¼	20 ,,	19½ ,,	18 18¾	10½ ,,	13½ 13¼	14 ,,
3. Breadth of plate beyond ring. R. L.	... ...	... ...	... ...	... ...	9 10½	13 ,,	13 ,,	11½ 12¼	2½ 2	5¼ 5	5½ ,,
4. Transverse diameter of rings. R. L.	... ...	... ...	... ...	... ...	6 6¾	7 ,,	6½ ,,	6½ ,,	8 8½	8¼ 8¼	8½ ,,
5. Greatest height of rings, vertically. R. L.	... ...	... ...	... ...	... ...	3½ 3⅞	4 4⅛	3¼ 3½	3¾ 4	6¼ 6½	6¼ 6⅜	6½ ,,
6. Circumference of rings. R. L.	... ...	... ...	... ...	... ...	15 16¾	18 ,,	15⅜ 16	17 ,,	25¾ 26¾	25¼ 25½	26 26½
7. Length of body.	4⅜	4	4½	4	4 2¾	3¾ 2¾	3¾ 3⅛	3½ 2¾	2⅝	2⅝	2⅞
8. Width of body: At anterior surface. At middle of side.					 ... 11	 ... 10½	 ... 12	 ... 11¼	 12½ 11½	 12 12	 13 12
9. Height of body.	...	4	4	3½	6½	7¼	7½	7½	6¼	8	8¾
10. Height of spinal canal.	...	7¾	8	8	5¾ 4½	5¼ 4	5½ 3¾	5⅛ 4⅛	4	3½	3¼
11. Width of spinal canal.	4¼	4½	4⅛	4⅜	6¼ 7⅛	6 6⅞	6 7⅛	6¼ 6⅞	6¼	7	6¾
12. Circumference of spinal canal.	...	...	...	...	19	17½	17¼	17¼	16½	17⅛	16¾
13. Length of spinous process.	1¼	¾	¾	?	3½	1	2¼	½	½	⅛	⅛
14. Greatest height of vertebra.	14¾	14¼	14½	...	16½	13¾	16	14	13	12¼	12¼
15. Weight. Pounds. Ounces.	19 11½	19 8	20 ...	... ...	23 10½	22 15	27 6	22 ...	8 13	7 9½	8 11

GREAT FIN-WHALES OF SAME SPECIES. (B. Musculus.)

4th.			5th.			6th.			7th.			1st. Dorsal.		
P.	S.	W.	P.	S.	W.	P.	S.	W.	P.	S.	W.	P.	S.	W.
32¾	36¼	38	34	37¾	38¼	32¼	36¼	36½	30	32	34¼	32	32	34
10½ 11	12½ 12¾	13½ ,,	11½ ,,	13½ 14	13¾ ,,	11 ,,	12¾ 13	13 13¼	11 11¼	11¾ 11	13 ,,	12½ 13½	11¼ 11¼	13 12¾
2½ 3⅛	4¼ 3¾	5½ ,,	4¼ 4	5 5¼	6¾ ,,	4 3½	4¼ ,,	5 5¾	2¾ 2¼	3 2½	... ...	... ...	... ...	... ...
7⅞ ,,	8¼ 9¼	8 ,,	7¼ 7½	8½ 8¾	7⅛ ,,	7 7½	8½ 8¾	8 7½	8¼ 9¼	8¾ 8½	... ...	... ...	... ...	... ...
6 ,,	6½ 6¼	6 ,,	6 ,,	6½ 6¼	5¼ 5½	7 ,,	... ...	6 ,,	... ...	... ...	... ...	... ...	... ...	... ...
25¼ 25	26¼ 27½	24⅛ 24¼	23½ 24	24½ 25¼	21⅛ 21⅝	24 25¼	26¾ 27¾	22½ 21½	... ...	... ...	... ...	... ..	... ...	... ...
2¾	2⅞	3	3	3⅛	3⅛	3¼	3⅜	3½	3¾	3⅞	4	4¼	4⅜	4½
12¼ 11¼	12 11½	12¾ 11¾	12 11	11½ 10¾	12¼ 11¼	11¾ 11	11¼ 10¾	12 11½	11¾ 11	11¾ 11	12½ 11½	12¼ 11¼	12¼ 12	13 12½
7½	8¼	9	7¾	8½	9½	8	8½	9½	7¾	8½	9½	7½	8¼	9
3¾	3¼	2½	3¾	3	2¼	3¾	3	2⅜	3¾	3⅛	2⅜	4	3⅛	2¾
6⅛	7⅛	7½	6¼	7⅛	7½	6¼	6⅞	7¾	6	6¾	7⅝	6	6¾	7¼
15¾	17⅛	17⅜	16	17¼	17⅜	16	16¾	18⅛	15¾	16¾	18	16	16½	17½
1	½	⅜	1¼	1	¼	2¼	1¼	¾	3¼	2¼	1½	2¾	2	1½
13½	12½	12½	13½	13⅛	12½	14¼	13¼	13	16	14½	14	15	14	14
7 4	8 ...	7 11	8 6½	9 6	9 7	8 2	8 6	9 15	10 6	11 15	13 3	14 6½	14 8	14 15

cesses (No. 13) is taken from within the canal, afterwards deducting the thickness of the lamina; the difficulty of fixing on the point of commencement of the spine rendering all other methods liable to fallacy. The distinction of right and left in the lateral measurements (the right always given first) shows the frequent a-symmetry, and that, when there is a difference on the two sides, there is no general preference of one side more than the other, as will appear farther from the remarks on parts not noticed in the table.

8. Bodies.—The bodies diminish in length (thickness) forwards, from the 7th to the 3rd. They gain in width, and lose in height, forwards, from the 6th to the 3rd. Longitudinally, they are grooved all round, except where the groove is interrupted by the median ridges and filled up by the roots of the inferior transverse processes. If the measurement of the width is taken at the middle of the groove it will generally give from $\frac{3}{4}$ to 1 inch less than if taken at the edges. The bodies are marked below, above, and on the sides by vascular foramina, largest below and smallest on the sides, more or less arranged in two rows, especially on the sides, one row going before the other behind the roots of the transverse processes. The breadth of the articular surfaces greatly exceeds the height, the proportion averaging that of 3 to 2 (see Fig. 4). The form of the surfaces varies in the three series, suggesting the semilunar in the Peterhead, the square in the Stornoway, and the oval form in the Wick series. The fundamentally square form arises from the projections where the inferior transverse processes and pedicles spring, forming lower and upper lateral angles. By the former being placed farther out, a greater breadth is given to the lower than to the upper part of the body, but the broadest part is generally a little below the middle. If the body is concave to the spinal canal, and the pedicles more internal, the semilunar form is given; if it rises up so as to be convex to the spinal canal, and the lower median ridge be also broadly developed, as in the Wick vertebrae, the form is changed to the oval. The posterior surfaces are, transversely, a little concave from the axis to the 5th, decreasing backwards; while the 6th is flat, the 7th and 1st dorsal a little convex. The anterior surfaces are convex transversely (and also a little convex verti-

cally), diminishing backwards, but distinct on the 6th and 7th. The striated ring, about 1½ inch broad, for the attachment of the capsular part of the fibro-cartilages, is well marked for an inch in breadth, and is convex, owing chiefly to the bevelling at the edges of the bodies; the inner half inch is concave and the concentric lines are less distinct. The contained somewhat figure-of-8 space, corresponding to the pulp, presents generally a central elevation, with a large shallow depression on each side bounded by a raised enclosure (see Fig. 4). The central elevation is seen on both surfaces, best marked perhaps on the front surfaces especially of the anterior vertebrae, while on the hinder surfaces it is better marked on the posterior vertebrae. Hence the bodies are thickest in the centre, where the measurements given in the table were taken. They measure ¼ inch less at the ring just within the bevelling, and about ¾ inch less at the extreme bevelled margins.

9. SPINAL CANAL, LAMINAE, ANAPOPHYSES, SPINOUS PROCESSES.—In my account of the Peterhead Razorback[1], I alluded to the high arches and well marked spines in it, compared with the low arches and scarcely present spines in the Wick specimen. Also in the latter, to the extreme thinness of the anterior border of the laminae, indicating atrophy. In both these respects the Stornoway specimen is intermediate, although in regard to shortness of spinous processes it more resembles the Wick specimen. The difference in the *shape of the spinal canal* is great, being triangular in the Peterhead and semilunar in the Wick series. The semilunar form is owing partly to the raising of the floor of the canal, the bodies (at their edges and median ridge) having become convex instead of concave to the canal; partly to the neural arches being very low. But the capacity of the canal, as the measurements of circumference show, is not less, being extended laterally by the pedicles being placed farther out on the bodies. On the four posterior vertebrae, while in the Peterhead specimen the height is more than half the breadth, in the Wick specimen the height averages less than a third of the breadth. The one is fully 1¼ inch greater in height, while the other is 1¼ to 1½ greater in breadth and 1½ to 2 inches greater in circumference.

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[1] In this *Journal*, Nov. 1871, p. 120.

The lowness of the arch is not owing to shortening of the pedicles, but to the laminae turning across with very little rise, and forming no angle at the middle. The semilunar form is less marked on the 3rd, the body being a little concave and the arch a little raised at the middle; behind it all the bodies are convex, increasingly so backwards; the arches rise a little at the 6th and 7th, being lowest at the 4th and 5th; at the 5th the curves of the body and of the arch are almost parallel. In the Peterhead series all the bodies are concave and all the arches triangular.

The *laminae* of the posterior vertebrae do not overlap, leaving more or less open, in the Wick specimen the two, in the Peterhead three, and in the Stornoway specimen the four posterior spaces; most open in the Peterhead, elliptical and unsymmetrical in the other two specimens; and in the Peterhead and Wick specimens there is a median space between the laminae of the axis and third. In each there is a series of well marked processes projecting backwards (*anapophyses*) from the outer part of the laminae, near the articular processes. In the Wick specimen (see Fig. 3) they are 1 to 1½ inch in length, about two inches in breadth (about one-third of the lamina transversely), directed backwards and a little upwards, taper to a blunt rough point, and evidently receive their soft attachments from behind. On the 3rd, 4th, and 5th vertebrae they are much larger and longer than the atrophied spines, which are mere narrow median roughnesses, with a slight peak posteriorly. On the three hinder vertebrae they are considerably longer on the left than on the right side. In the Peterhead specimen (in which the spines are well marked) these anapophysial processes are more internal and less marked, though quite distinct, except on the 6th and 7th, on which they are obscure. In the Stornoway specimen they are intermediate. In front, they commence strongly marked on the axis, while posteriorly, on the 7th, they merge with the posterior articular process; but along the neck they are internal to and quite distinct from the articular processes.

10. ARTICULAR PROCESSES.—These processes are in a very reduced condition for vertebrae of this size. The anterior face nearly straight up, but with a little inclination outwards and

also forwards, the posterior the reverse. The size of the cartilaginous surfaces varies a good deal from the 3rd to the 6th, averaging 1½ to 2 inches by 1, the ellipse or oval being placed transversely, or rather obliquely upwards inwards and backwards, nearly in the direction of the laminae, on which most of the facet of the posterior is placed, the anterior being more on the "process," which projects from about ¾ inch on the 3rd and 4th to from 1 to 1½ on the 6th and 7th vertebrae. They become longer and more oblique between the 6th and 7th, and still more so between the 7th and 1st dorsal. Between the axis and 3rd they are nearly twice the size of those of the succeeding vertebrae, and present in all the four specimens irregularities and pits, giving a worm-eaten appearance to the surfaces. When well formed, the surfaces of the anterior processes are from within outwards first convex, then concave; those of the posterior the reverse. They are best marked in the Peterhead, and least in the Stornoway series.

11. INFERIOR TRANSVERSE PROCESSES.—Those of the 3rd, 4th and 5th, complete in all the specimens, may be first compared. The *root* springs from the lower part of the side of the body, placed nearer the anterior than the posterior surface, varying in the amount of forward and backward expansion which it undergoes in joining the body, the 4th being thinner than the 3rd and 5th. The root has a broad attachment vertically, like the pedicle which supports the superior process, and as broad as it, but thicker in accordance with the greater thickness of the inferior processes. The roots are concave and smooth on both surfaces. The *tubercular stage*, nearly on the same line internally, increases in length forwards to the 3rd. The projection of the inner angles, besides being downwards is also forwards on the 3rd and 4th, especially on the former, but backwards on the 5th (and on the 6th also, if the process is present), except in the Wick specimen, in which the projection on the 5th is forwards. The tubercular part rather diminishes outwards on the 4th and 5th, but increases on the 3rd, terminating in a great though variable projection, giving the 3rd the longest and largest tubercular stage. The *nerve-groove stage* is well marked in all, best on the 5th. The twist seen on the anterior surface of the processes is owing, internally, to the

tubercular stage being much thicker below than above, while the grooved stage is thin below as well as above; and, externally, to increased thickness and less inclination of the terminal plate. The posterior surface of the processes is inclined obliquely upwards to the lateral canal, nearly uniformly so on both the tubercular and the grooved stages.

When in position, the process of the *third* is seen, after rising forwards a little at the root, to slant very obliquely backwards, parallel to the lower edge of the process and wing of the axis, and to bulge more downwards than the axis in the Peterhead specimen and at the outer part on the left side in both of the other specimens. The *fourth* has less obliquity backwards, and is more slender throughout, than the 3rd. The *fifth* is nearly horizontal, is the process to which the others converge, and is the stoutest, especially externally, having to support the widest and thickest terminal plate. The conditions of the *sixth* in these three necks illustrate well the liability of the inferior transverse process of this vertebra to be more or less deficient. In the Wick specimen, it is complete on the left side, the stages well marked, but on the right side it is wanting at the nerve-groove stage; in the Peterhead specimen it is wanting at the nerve-groove stage on both sides; and in the Stornoway specimen a large part of the tubercular stage also is wanting, on both sides, on the left side little more than the root-stage being present. When this process is incomplete in length, it also wants the upper part (that which gives breadth to the other processes) partially at the root, but more especially at the tubercular stage. Hence the process is flattened in a direction the reverse of those in front of it, and appears to spring from the body farther in than the others, and the capacity of the ring is thereby incidentally increased. The incomplete process generally tapers outwards to a narrow round point. The other end of the gap is formed by a flattened pointed process which the upper transverse process sends inwards more or less. The appearance as if the two ends would not meet if prolonged, is owing partly to the natural twist of the grooved stage, partly to the two pointed ends not belonging to corresponding parts of the plate which would have united them had it been developed. In the Peterhead and Wick specimens, in which I had the opportunity of dissecting the soft parts, the processes were represented at these gaps by ligament between their cartilaginous tips[1].

The *seventh* shows, as usual, at most a mere rudiment of the root stage of the inferior process. It is seen in the Wick and Stornoway specimens; is better marked on the Wick 1st dorsal, less marked on the Stornoway 1st dorsal; not at all on the Peterhead 7th, but well enough marked on the Peterhead 1st dorsal. It is placed where the lateral and lower surfaces of the body turn round to each other, and is little more than a slight rough projection where the ligament was attached. It may occupy most of the length of the body, but is mainly on its posterior half.

12. SUPERIOR TRANSVERSE PROCESSES.—The *pedicles* from which these processes arise, about an inch farther in than the lower process, are opposite the fore part of the bodies, coming quite to the level of the anterior surface, and expanding backwards so as to occupy ½ (Peterhead specimen) to ⅔ (in the other two specimens) of the length of the body. They average 1½ inch in length along the middle to the zygomal process; increase in width backwards from the 3rd to the 7th; are grooved before and behind to form the intervertebral foramina; are directed upwards and outwards; and the inner half may be said to belong to the support of the neural arch and articular process, while the outer half sweeps outwards into the superior transverse process, serving as its root. Viewed in position, the *superior processes* converge outwards to the 5th, which is nearly level. Unlike the inferior processes, they gradually increase in strength backwards, the increase becoming more marked on the 6th, and greatly more on the 7th. At first, at the *nerve-groove*

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[1] In the *Wick* specimen the right inferior process is 4½ inches in length; after forming a forward and then a backward-projecting inner angle, it tapers rapidly outwards; gap now 3½ inches. Terminal expansion of upper process not so broad as on left side; pointed process sent in ½ inch internal to outer end of ring. In the *Peterhead* specimen both processes are 4½ inches long; inner angles developed backwards, left less than right; left more flattened, from greater deficiency of upper part, than right. Gap on right side 1½, on left 1 inch. Plate of upper process most expanded on right side; extent to which narrow process turns in, right side, 1¾, left 2¼ inches. In the *Stornoway* specimen the inferior process is 2½ inches long on right side, 1½ on left; left process flattened and tapering to blunt point; right much thicker than left, rounded and does not taper much; gap on right side 7¼, on left side 8¼. Plates of superior processes turn in for about ¼ inch, process on right side the most distinct.

stage, the surfaces are more directly forwards and backwards, giving the processes a slender appearance here, and leaving wide spaces between. The length of this stage increases forwards from the 7th to the 2nd. The *tubercular stage,* from the rough prominences which mark its commencement to opposite the outer end of the ring, has its surfaces inclined, the posterior looking obliquely downwards to the lateral canal. The anterior, looking obliquely upwards, is, in its upper half, rough and bevelled so as to look very much upwards, and is broadened so as to overlap the process behind it before the outer end of the foramen is reached. The inclination of these processes is most strongly marked on the 3rd and 4th, extending also to their nerve-groove stage; a little less on the 5th; on the 6th to a variable extent in the different specimens, in the Peterhead specimen throughout, in the Wick specimen scarcely at any part. On the 7th, on the contrary, the surface which looks obliquely to the canal is the anterior. This process is so thick as to present a third surface, looking upwards and rough, corresponding to the rough bevelled part on the anterior surfaces of the processes in front of it.

The general inclination of the posterior surfaces of both upper and lower processes, from the 2nd to the 6th inclusive, continued externally at their junction, gives the double transverse process the appearance of the section of a cone, the inner circumference, at the ring, being farther forwards than the greater circumference. It is seen on a large scale on the processes and wing of the axis. Although the most striking result of this is the presentation of a series of oblique surfaces, instead of narrow edges, as a bony wall to the lateral canal, it is to be regarded rather as the result of adaptation to the attachment of the ligaments and muscles on the under and upper aspects of the neck.

Viewed in series, the superior processes in the Peterhead and Wick specimens, from the 4th to the 6th, are nearly on the same level in point of height; the 3rd rises a little higher, the 7th rises higher throughout, and prominently so at its outer end. In the Stornoway specimen, the five posterior are on the same level, the 7th scarcely rising, except at the outer end.

The *terminal plates* are a little inclined towards the canal in their inner portion, continuing the inclination of the posterior surfaces of the processes above and below, but the inclination is less. The outer portion, when expanded, is less inclined, but the whole posterior surface has more or less of a concavity, increasing backwards, especially marked on the 6th and 7th; the anterior surfaces being correspondingly convex. The size of the terminal plates varies much according to age and the vertebra. They are much less expanded in the less mature Peterhead specimen than in the more aged Wick specimen. They increase in width backwards to the 5th (except in the Stornoway specimen in which the 3rd are as broad), which is in all the most projecting; and they diminish backward from it. In the Peterhead specimen the 3rd and 4th are blunt-pointed triangles, not much broader than the processes, the 5th forms a larger triangle. The 3rd, 4th, and 5th, in the Stornoway and Wick specimens, have expanded vertically as well as transversely to form more or less square-shaped plates (Fig. 4), the outer edge oblique, the lower angle the more prominent,—as seen on a large scale in the wing of the axis. The upper angle may not be developed, the plate retaining the triangular form, or so much developed that there is a hollow between the two angles. The 6th in all tends to broaden upwards, as a relation to the 7th, though the lower part is still the most prominent point. The extent to which the terminal plates may vary is well illustrated on the third vertebra; in the Peterhead specimen their breadth is 2½ inches (only ½ inch broader than the processes near them), while in the other two specimens they have expanded so as to present a breadth of 5 to 5½ inches, and a height, vertically at the inner part, of 6½ in the Stornoway, and 8 inches in the Wick specimen. The transverse process of the 7th forms a more or less square-shaped terminal expansion. In the Stornoway specimen it is very square-shaped, nearly at right angles to the rest of the process, the upper angle being, at least on the right side, the most extreme point. In the other two specimens it is rhomboidal, directed obliquely downwards and outwards, the lower angle the most extreme point, and less expanded in the Wick than in the Peterhead specimen. The outer edges present the rough unfinished appearance of ossifying bone; in the Peterhead specimen at the broadening points; in the more expanded Stornoway and Wick specimens, all along the outer edge and round the upper and lower angles, most marked in the Wick specimen[1].

Viewed in position, the 5th vertebra is, next to the axis, the most projecting, and its terminal plate is not only usually the broadest but is thicker, especially its lower part, than those of the 3rd, 4th, and 6th. It is the horizontal process, to which the others converge. The 7th is the least projecting in all. Next to the 5th in projection are the two next it; in the Stornoway specimen these two are equal; in the Peterhead it is the 4th on the left side, the 6th on the right; while in the Wick specimen it is the 4th, but in it the 3rd projects as far as the 4th. When the bodies are separated to the same extent as they are naturally by the fibro-cartilages, the terminal plates, though near each other, are not in contact; the thin wedge-shaped spaces diminish outwards until there may be only from $\frac{1}{8}$ to $\frac{1}{4}$ inch between the tips; but they may be made to touch by a little lateral flexion, or the more slender ones by their flexibility when the tips are pressed with the fingers. The following measurements of the Wick and Stornoway specimens indicate the amount of the convergence. At the roots of the inferior processes the extreme distance between the third and sixth is 10 to $10\frac{1}{2}$ inches; between the tips, including the thickness of the four plates, $2\frac{1}{2}$ inches. Including the axis and the 7th, the extreme distance between their superior roots averages 18 inches, while externally they reach the same level.

13. THE RINGS.—The characters of the rings (foramina) are seen when the vertebrae are laid in series on the floor. In *form* they are between a triangle and a semi-oval, the inner boundary obliquely convex, the upper and lower concave; the upper angle acute, the lower obtuse, the outer rounded off (Fig. 4).

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[1] The *thickness* of the terminal plates, when expanded, as in the Wick and Stornoway specimens, from the 3rd to the 6th, averages about half an inch, at the middle; the 4th is the thinnest, the 5th the thickest. They are generally rather thinner internally towards the ring, and thicker towards either the upper or lower margin, towards the upper in the 3rd and 4th, towards the lower in the 5th. The fifth in the Wick specimen is $1\frac{1}{4}$ to $1\frac{1}{2}$ inch below, $\frac{1}{4}$ to $\frac{1}{2}$ inch above; in the Stornoway specimen there is marked a-symmetry (Fig. 4), on the right $\frac{7}{8}$ below, $\frac{1}{2}$ above; on left side 1 inch below, $\frac{3}{4}$ above. The 6th in the Wick specimen is $\frac{3}{4}$ inch thick on the side on which the inferior process is complete, and much thicker below ($1\frac{1}{4}$) than above ($\frac{5}{8}$), while on the right the plate is under $\frac{1}{2}$ inch and nearly uniform. The 7th is thicker (1 to $1\frac{1}{4}$) and less expanded than the others.

The oval form is more marked in the anterior, the triangular form in the posterior vertebrae. The upper margin is the longest, partly from the pedicle being set on the body about an inch farther in than the inferior transverse process is, partly from the outer end of the ring being below the level of the transverse axis of the body. This margin does not rise higher than where it begins, but curves gradually outwards and downwards. The lower margin is generally the most bent, varying a good deal (from $\frac{3}{4}$ to $1\frac{1}{4}$ inch) in the degree to which it is bent down at the tubercular stage; and the outer half varies in the degree of its curvature, in some turning up more abruptly so as to give the appearance of an angle on the lower edge of the ring, in others having a more continued concavity. The greatest vertical height of the rings (as given in the table) is at about the junction of the inner and middle thirds, and is about $\frac{1}{4}$ to $\frac{1}{2}$ inch greater than at the middle of the ring. If the line of the transverse axis of the bodies be prolonged, it intersects the rings variously; in the 2nd, $\frac{2}{3}$ are above the line; in the 3rd, there is rather more above than below (except in Stornoway right, most below); the 4th is about equally divided (except in Stornoway left, most above); in the 5th most below (except in Stornoway left, rather most above); in the 6th most (from $\frac{3}{5}$ to $\frac{2}{3}$) below. A line intersecting the outer ends of the rings (foramina) leaves on an average $\frac{2}{3}$ of the rings above it, and intersects the bodies so as to leave $\frac{3}{5}$ above (on the sixth $\frac{2}{3}$) the line. The extreme tips of the transverse processes are below the line of the transverse axis of the bodies, and are mostly below even the transverse line intersecting the outer ends of the rings, but the tips generally are on a line with the general axis of the foramina and double transverse process, the direction of which is outwards and downwards. The *size* of the rings generally decreases a little backwards from the 3rd to the 5th (except in Stornoway 3rd, in which it is not so large as in the 4th), as the measurements given in the table show. The slight increase in capacity at the 6th is chiefly owing to the deficiency in the height of the root of its inferior transverse process. It will be observed, from the measurements given, that the expansion of the terminal plates is not, as in the case of the axis, accomplished at the expense of the foramina; for, although the foramina are a little less in the Wick than in the Peterhead specimen, they are (except in the 3rd) larger all through in the Stornoway than in the Peterhead specimen, while in the latter the plates are much less expanded than in the other two. The gain is by outward growth beyond the rings. The table of measurements shows frequent want of symmetry in the diameters and capacity of the rings on the two sides of the same vertebra.

14. RECOGNITION OF THE FIVE POSTERIOR VERTEBRAE.—These vertebrae may be distinguished from each other by the following characters.

The *third* and *fourth*, from the others, by their transverse processes slanting obliquely backwards. The articular processes indicate front and back, the anterior facing upwards. The *third* is known from the *fourth* by the greater slant of the transverse processes, making it like a bow when resting on the floor, and by the far out position and great development of the outer end of the tubercular stage of the lower transverse process. The *fifth* is known by its transverse processes being directed nearly horizontally outwards. The *sixth* by the transverse processes being directed a little forwards, but more readily by the inferior transverse processes being usually more or less incomplete. The *seventh* is known, from the sixth, by its robust superior transverse process, and the almost entire absence of a bony inferior transverse process; and from the first dorsal, by its transverse process being less robust, and being flattened, especially at the outer end, while the ends of the first dorsal are thick and rounded.

15. THE AXIS.—(*a*) *Transverse processes.* This enormous process, when fully developed, may be divided into three parts of nearly equal length,—the processes and foramen, the broad square part of the wing, and the tapering part of the wing. The *ring* is so small as to be scarcely equal in circumference to the spinal canal of the vertebra, except in the Stornoway specimen, in which it slightly exceeds it. It is ovoid, the lower boundary the most curved, the outer end rather the most pointed. The smaller size of the ring of the axis is owing to the increase of the processes and inner part of the wing at the expense of the ring. The extreme height of the processes opposite about

the middle of the ring is very little greater than that of those of the 3rd vertebra, but they are so developed both in height and thickness that they are twice the breadth (height), and two or three times greater in circumference. The increase is greater relatively on the superior process, but the inferior process is actually the greatest, corresponding to the greater extent of the lower part of the wing. The *wing* corresponds to the terminal plate of the vertebrae behind, enormously expanded. Although it presents very various forms with age and individual variation, definite characters may be recognised. From having been square-shaped, it has become prolonged at the lower part, giving the outer border a very oblique direction, and rather a triangular appearance to the wing. In a young specimen in my possession[1] the processes are as yet flat, the lower twice the height of the upper, the plate beyond the ring is only half the length of the ring, and a line is seen running across it, from the outer end of the ring, where the two have united, leaving much the broadest part of the wing opposite the inferior process. In the four grown specimens the prolongation of the axis of the ring leaves $\frac{2}{3}$ or $\frac{3}{5}$ of the breadth of the wing opposite the lower process, except in the Peterhead specimen, in which the division is about equal.

When the wing is developed, the *outer border*, oblique and undulating, presents more or less of a concavity which may (as in the Peterhead specimen) be partially subdivided by a prominence. The *inferior border* is thick and rough on the process opposite the tubercular stage of the vertebrae behind, and then sweeps outwards to the tip with a general convexity downward. The *superior border* presents first a well-marked stage corresponding to the nerve-groove stage of the other vertebrae, terminated externally by a tubercle where the border is rolled upwards and forwards, corresponding to the series of tubercles on the processes behind, and before to the hinder projection of the transverse process of the atlas. The atlo-axoid intertransverse

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[1] Without history, but it is evidently that of a young great Finner. It has the following dimensions. Greatest height 12 inches; greatest width $23\frac{1}{2}$; width of lateral ring, right $3\frac{3}{8}$, left $3\frac{5}{8}$; height of lateral ring, right 2, left $2\frac{1}{4}$; circumference of lateral ring, right 9, left $9\frac{1}{2}$; width of plate beyond ring, right $2\frac{1}{2}$, left 2; width of spinal canal, anteriorly 5, posteriorly 6; height of spinal canal, anteriorly $4\frac{5}{8}$, posteriorly $4\frac{1}{4}$; circumference of spinal canal, $15\frac{1}{2}$.

ligament was found to be attached here in the dissection of the lesser Fin-whale. This tubercle is at the broadest (highest) part of the wing, and is nearly opposite the outer end of the ring. From the tubercle to the upper angle is the tubercular stage of the process and wing; it is rough and bent backwards, forming a considerable concavity transversely, giving a very undulating appearance along the upper edge of the process and wing (see Fig. 3).

The extent to which the wing is expanded varies in both directions. The length outwards to the superior angle is nearly the same (12 to 13 inches, from the edge of the inferior surface of the body) in all the four grown specimens, except on the right side of the Wick specimen, in which it is 2 inches more. The length to the inferior angle varies in these four, from 15 inches in the Peterhead (right side, left $17\frac{1}{4}$) to 20 in the Stornoway specimen. The broadest part of the wing is nearly opposite the outer part of the ring, where the processes are tubercular, especially the upper; but the breadth (height) is not very much greater than that of the processes farther in, being about 2 inches greater in the Wick (height of wing $12\frac{1}{2}$), 1 to $1\frac{1}{2}$ in the Peterhead (right wing $10\frac{3}{4}$, left 11), 1 in the Norway (10), $\frac{1}{2}$ to $\frac{1}{4}$ in the young ($8\frac{3}{4}$, $8\frac{1}{2}$), and in the Stornoway specimen 1 inch on the left side, none at all on the right ($10\frac{1}{4}$, $9\frac{3}{4}$). From this point, to opposite the upper angle, being along the inner half of the wing, the breadth diminishes somewhat at both borders, and on the outer third rapidly by the obliquity and concavity of the outer edge. The outer 5 inches in the fully grown Stornoway specimen is abruptly marked off as a nearly equilateral triangle, rounded at the tip, and is bent backwards so as to give this part a much greater slant than the inner part. It is at the same time twisted, so that its posterior surface looks partly upwards. The processes and their wing are curved transversely, concavity backwards, the depth of the curve, from the ring outwards, being about an inch when the tips are much bent. The wing is also curved vertically, depth of curve 1 to 2 inches, influenced by the amount of bending of the margins, but well marked over both the surfaces, convex in front, concave behind. The thickness of the wing at the middle is about an inch, increasing inwards, diminishing outwards to from $\frac{3}{4}$ to $\frac{1}{2}$ inch at the tip.

When *in position,* the wings of the axis, in the Stornoway specimen, are seen to pass outwards beyond the tip of the transverse process of the 5th more than two inches; and backwards as far as fully to the level of the tip of the transverse process of the 7th, and to the level of the junction of the anterior and middle thirds of the body of the 6th. In the Peterhead specimen the wings extend two to three inches (over 2 on the right, over 3 on the left) outwards beyond the 5th; but backwards only to the level of the tips of the transverse processes of the 4th, and to the level of the hinder edge of the body of the 4th. In the Wick specimen (as accurately as can be determined in the partially injured condition of the extreme tips) they reach outwards four inches beyond the 5th; and backwards to the level of between the tips of the transverse processes of the 6th and 7th, and to the level of the hinder part of the body of the 5th, but they may have been longer. Taking all the five specimens, the distance to which the slant of the wings carries their tips back from the level of the hinder surface of the body, is, in the Stornoway specimen 10 inches, Wick apparently 8, Norway 8, Peterhead 5½, young specimen 1¾ inch. Vertically the inferior transverse process is seen to project less downwards than the tubercular stage of the process behind it, and the superior process scarcely if at all projects above the level of the inner stage of the superior processes behind it, but all beyond these points the wing and upper process of the axis project beyond the processes behind them, upwards, downwards and outwards, forming a great sloping shield in front of them.

(*b*) The region of the *spinous process* of the axis presents very great variety. The Wick and Stornoway specimens resemble each other in presenting a large square-shaped mass, partially bifurcated in the former, while, in the Stornoway and Norway specimens, this part is flat with two low widely-separated longitudinal ridges, or crests, in the valley between which there is a low median ridge. The mass is apt to be regarded as a greatly developed and more or less bifurcated spine, but the central ridge must be regarded as the true spine, the lateral ridges being processes on the laminae, serial behind with the anapophysial processes, and anteriorly forming projections on which there may be true articular facets for articulation with the atlas. Hence the spine appears in the table of measurements, in one, $\frac{1}{2}$ an inch, in another, $3\frac{1}{2}$ inches in length. We have here a striking illustration of how easily one might be misled in endeavouring to found distinctions of species on the conditions of the bony processes[1].

(c) *Anterior aspect of the body of the axis.* There is considerable variation in the depth of the articular surfaces, in the form of the odontoid area between them, and in the form of the odontoid process. The greater depth of the *articular cavities* is owing to the greater rising up of the outer sides. In the Wick and Peterhead specimens the greatest depth on each side, as given by a line laid on between the outer edges at their fore part, is $1\frac{3}{4}$ inch; in the Stornoway specimen $\frac{3}{4}$, in

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[1] We can see how the one form may grow into the other. In the *young* specimen, the lateral ridges, or crests, rise about an inch, are 4 inches apart, diverge backwards, and in the valley between them there is a low median spine. In the *Norway* specimen the lateral crests are two low irregular convex ridges, 5 inches apart, rising scarcely half an inch, except forwards, where they support articular facets, while the median ridge, in the very shallow valley, rises at most half an inch. The anterior part of the crests and valley begin to meet the posterior part at an angle, and the posterior part is the roughest. In the *Stornoway* specimen, the crests, $4\frac{1}{2}$ inches apart, have increased both in height and thickness, especially forwards, the valley is an inch in depth at the fore part, much less behind, and there is a low median ridge; and the angle between the fore and back parts is increased, but is still very obtuse. In the *Wick* specimen (see Fig. 3) the crests are largely developed forwards, but still more backwards, the valley between them being at the same time well filled up. The angle between the fore and back parts of the crests and valley has risen up to a right angle. The valley in the fore part is nearly filled up, while in the back part it presents a very rough excavation. The whole has the appearance of a great square-shaped mass partially bifurcated backwards and with a tendency to bifurcate upwards, without median ridge anywhere. In the *Peterhead* specimen the change is carried farther, the angle is carried upwards and backwards to an acute angle, the fore part is quite filled up, the back part concave and rough. The square lump of bone thus formed presents sloping lateral surfaces, giving a width of 6 inches to the process at the middle; a square-shaped superior surface looking forwards as well as upwards, about 4 inches square, projecting more on the left side than on the right; a thick anterior border; and posteriorly, marked off from the fore part by a sharp transverse overhanging edge, an excavated surface, looking backwards and a little upwards, 5 inches across by $3\frac{1}{2}$ vertically, excavated to a depth of $1\frac{1}{4}$ inch, very rough, and with a median ridge.

This great variation is not a matter of age, for the form presented by the young specimen is retained by two of the mature specimens, while the more developed form is presented by the mature Wick and the scarcely mature Peterhead specimen; unless we suppose that this part having begun as in the young specimen, progresses under muscular action to the condition of the square-shaped mass presented in the Peterhead specimen (in which the other cervical vertebrae have the spines most fully developed), and afterwards becomes reduced with age to its early condition, the three other specimens showing stages of that reduction. But in the Wick specimen, in which the spines of the vertebrae behind have nearly disappeared, this part of the axis presents the next best instance of massive development. These differences must therefore be regarded mainly as exhibitions of individual variation.

the Norway specimen intermediate. This difference is strikingly seen from below when the bodies are in position, the atlas appearing in the two former to sink into a deep cup in the axis, while the depression is comparatively shallow in the Stornoway specimen. This gives the appearance of considerable difference in the length of the body at the sides, while at the middle below they are mostly the same, as seen in the table of measurements. Together with greater depth of the lateral cavities, there is a sharpness of finish all round the edges of the horse-shoe surface, in marked contrast with the Stornoway specimen. The articular edges in the latter are over half an inch lower than the odontoid, in the Norway specimen $\frac{3}{8}$ inch below it, in the Peterhead and Wick specimens nearly (Peterhead scarcely, Wick rather above) level with the odontoid, but the odontoid is actually the longest in the Peterhead specimen. The upper of the two series of measurements of the length of the body given in the table are taken at the odontoid, and show it to be $3\frac{3}{4}$ inch each in the Wick and Stornoway, and 4 in the Peterhead specimen.

The *odontoid* appears to the eye to vary a good deal in length, but this is mainly owing to its form. In the Peterhead specimen, in which it appears long, it rises to a height of an inch from the edge of the odontoid area; in the other specimens about $\frac{1}{4}$ inch less. In the Peterhead specimen the area and process together form a cone, rising well but not abruptly at the process; in the Wick specimen the area is less raised, the process rather more defined at its base; in the other two grown specimens there is only a low general cone, rising to a blunt summit, lowest in the Stornoway specimen. In the young specimen the cone rises better, and is terminated by a blunt excavated apex. In all of them the summit is below the middle of the area (at about the junction of the lower and middle thirds) but above the middle (nearly as high as the junction of the upper and middle thirds) of the general body of the axis. In height, the odontoid area is nearly the same (nearly $3\frac{3}{4}$ inch) in all, except in the Norway specimen in which it is fully $4\frac{1}{2}$, but it varies a good deal in breadth. The following are the breadths of this area, and, given within brackets, the breadth of the entire anterior surface of the body—Peterhead $4\frac{1}{2}$ (15), Stornoway

5 (13½), Wick 5¾ (15), Norway 6¼ (15), young specimen 6¼ (12½). The area is much rougher on the inner half or two-thirds than on the outer part, and is especially rough on the process and below it. In the Stornoway specimen, in which the articular surfaces are shallow, the edge between them and the odontoid area is not so sharply defined as in the others.

16. Atlas.—(*a*) The *posterior surface* presents differences corresponding to those noticed on the anterior surface of the axis. The transverse convexity of the lateral *articular surfaces* is strongly marked in the Wick and Peterhead specimens, the surfaces of the latter being specially prolonged outwards and terminated by a raised edge, so that they become concave externally. In the Stornoway specimen, the surfaces are much more flat, the internal convexity is low, and the external concavity is distinct, although the outer edge, instead of being prolonged, is so deficient that its upper half is bounded by a concave instead of a convex line, and is so low as to be nearly on a level with the transverse process. The *crescentic ligamentous surface,* internal to each lateral articular surface, varies in breadth with that of the odontoid area, to which the two crescentic surfaces and the odontoid division of the canal correspond, and also in sharpness of definition. In the Stornoway specimen it reaches 1 inch in breadth, and is not much depressed; in the Wick specimen (see Fig. 5) 1¾ in breadth, and is abruptly depressed more than ¼ inch; in the Norway specimen fully 1¾ in breadth, and is obliquely depressed.

(*b*) The *anterior articulating surfaces* vary in the state of their edges, in their depth, and in the breadth of the median groove. In the Peterhead and Wick specimens the edges are sharp, giving the cavity a depth of 3 inches; in the other two specimens the cavity is nearly half an inch less in depth, the edges being lower and more rounded, sinking especially at the sides to the level of the transverse processes. All show the furrow round the outer side for the attachment of the capsular ligament. The median groove is narrowest in the Wick and Stornoway specimens, broader (⅜ inch) and more defined in the Peterhead, broadest (⅝ inch) in the Norway specimen. In all it widens out triangularly below, and also a little above, being narrowest at or above the middle, but in the Norway specimen it remains widely open, and presents a double furrow in its floor, indicating the separate attachment of the two capsular ligaments. The measurements of the cups of the atlas are; greatest height and breadth (diameters) of each, Peterhead specimen 11 by 6 inches, Stornoway 10¼ by 5¼ (wanting an inch in height at the upper part from not extending up over the roof of the transverse foramen, as the others do), Wick 11¼ by 6, Norway 11 by 5⅜; distance between the outer edges of both cups, given in the same order, 13½, 12½, 13½, 12¾.

(c) *Parts on the neural arch. Occurrence of articular processes between the axis and atlas.* The spinous process is distinct in all as a median ridge, most marked posteriorly, very little marked on the anterior half in the Stornoway and Wick specimens. It is most developed in the Peterhead specimen in which the axis is so greatly developed here, but it is on the whole scarcely more pronounced in the Wick than in the Norway specimen, in which the spine of the axis is so differently formed. On each side of the spine, about the middle of the lamina, rough lateral ridges occur, serial with the crests on the laminae of the axis, increasing and diverging forwards (see Fig. 3). The ridge runs forwards into the process which arches over the nerve-notch of the atlas and usually converts it into a foramen, and backwards more or less into a posterior articular process for the axis. True *articular processes* between the axis and atlas, situated above the nerve-escape, existing normally in reptiles and birds but not in mammals, are present, more or less, in at least four of these five great Fin-whales[1]. They are present on both sides in the Norway and Stornoway specimens, on the right side in the Wick (see Fig. 5) and the left side in the Peterhead specimen, and seem to have existed on both sides on the young axis. On the axis they are situated on the lower part of the anterior end of the crest-like ridge, above the middle of the lamina, and from their position the facet is very liable to be rubbed off and overlooked. The facets on the atlas in the Norway specimen are symmetrical, 1½ to 1¾ inch transversely by about 1 inch longitudinally; in the Stornoway specimen they are elliptical pits, that of the left side divided into

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[1] I find them still better developed in some male Narwhals, on one or on both sides.

two, into which corresponding projections of the axis sink. From the greater development of the crest on the axis making it overlap the atlas, the facet is seen on the upper aspect of the lamina of the atlas, but in the Peterhead specimen it is on the under aspect, as the atlas is here the overlapping bone. In the Peterhead specimen this functional articular facet ($1\frac{1}{4}$ by $\frac{1}{2}$ inch) is situated high up where the spine and lamina join and partly on the spine, on the left side, owing to the great upward projection of especially the left side of the square-shaped mass of the axis. On both sides in the Peterhead specimen, and on the left side in the Wick specimen, there are low projections on the laminae of both bones, not meeting, corresponding to the ligamentous boundary superiorly of the intervertebral foramen. This foramen thus marked off above, of an oval form, admitting from three to four fingers, is rather larger than the two succeeding foramina, but not larger than the foramina between the three posterior cervical vertebrae.

(*d*) The *transverse foramen of the atlas* is incomplete on both sides in the Stornoway specimen; on the left side half an inch is wanting, on the right side $\frac{1}{8}$ inch. The posterior process is short especially on the left side, four-fifths of the nearly completed foramen being opposite the anterior process, which curves back from the end of the articular cavity. It is triangular in form, the deficiency in the roof being on the inner side, leaving the internal aperture unformed; and the articular cavity does not reach upon this part as it does in the other specimens[1]. The breadth of the arch of bone roofing over the foramen (giving also the length of the foramen or canal) is, in the Wick specimen, 2 inches on the right side, $2\frac{1}{2}$ on the left; Norway specimen, right $1\frac{3}{4}$, left 2; Peterhead specimen, right $1\frac{3}{4}$, left $1\frac{1}{2}$. The thickness in the Wick specimen is 1 to $1\frac{1}{2}$ inch, in the other two specimens $\frac{1}{4}$ inch less[2]. In the Stornoway specimen

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[1] This variety resembles that often seen in the human atlas by the more or less complete ossification of the ligament which normally arches over the nerve and artery. The serial correspondence of the posterior process to an articular process is evident, but it joins in front with a process of the same vertebra. The same arrangement is seen in the axis of some mammals, the anterior notch being converted into a foramen. In some the posterior notch in the dorsal region is converted into a foramen, the articular processes being also present.

[2] The articular cup being prolonged on this arch as far up as to opposite the middle of the foramen, the edge of the bone receives a forward curve in its upper

the recurved process is an inch in breadth at the middle, and ⅓ inch thick. In dissecting the Peterhead specimen I found the roof to be naturally continued outwards for over half an inch by a ligamentous arch, thick where attached to the bony edge, becoming thinner to the crescentic margin in which it terminated externally. The broad groove issuing from this foramen is continued outwards to the anterior surface of the root of the transverse process, and a narrower groove is seen to pass nearly straight backwards from the outlet of the foramen to a notch on the lower edge of the lamina at the intervertebral foramen between the atlas and axis (see Fig. 3). The foramen contained, besides the atlantal nerve (about the size of the human great sciatic), a plexus of small vessels, one as large as a crow-quill, but no large vessel. The foramen is less than a third the size of the intervertebral foramina; roughly, it will admit a thumb. It is smallest at the inner end, which is oval in the Wick specimen (long axis longitudinal and nearly 1 inch), smaller and round in the Peterhead, intermediate in the Norway specimen. In the Stornoway specimen, in which the roof is incomplete, the oval is vertical and the capacity greater.

(*e*) The *transverse process* of the atlas is in series with the superior process of the axis. Internally, the process is flattened, the surfaces forwards and backwards, but thick enough to present upper and lower surfaces, the expanded root situated opposite the upper half or two-thirds of the articular surface, or so-called body, of the atlas, the downward extent of this attachment varying, and being at first so gradual that it is not easy to define its commencement. Externally, it is flattened in the opposite direction, the surfaces inferior and superior, with upper, lower, and external borders. Variations are seen in the different specimens, as observed both in vertical and antero-posterior views. *Observed in front,* the processes in the Wick specimen (as seen in Fig. 5, representing a posterior view) stand out transversely, as stout triangular or conical processes, the right broadest (highest) externally, the left broadest at the root, which passes down 1½ inch below the middle of the body. In the

third, making the length between the posterior and anterior surfaces about an inch more above than below in the specimens in which the arch is complete. When the vertebrae are built up vertically, the upper third of the cup is consequently seen to rise to a higher level than the rest.

Peterhead specimen they pass straight out, are much thinner in the outer half, the upper margin forming a general concavity along its outer three-fourths, and the root is opposite very little more than the upper half of the cup. In the Stornoway specimen the root is opposite the upper $\frac{2}{3}$ of the cup, passing $1\frac{1}{2}$ to 2 inches below the middle, but, as the upper inch of the cup is not developed, the middle is a lower point in this specimen than in the others, and the processes therefore extend fully to the beginning of the lower third of the cup. It widens out sooner on the left than on the right side. A little more filling up about the middle of the lower margin would give these processes the form of triangular masses set opposite the upper $\frac{2}{3}$ of the cup; and I should have great hesitation in accepting the extent of this attachment as a character in distinguishing species. The upper margin of the process is sigmoid, first broadly convex, where the other two specimens show only the internal tubercle, and then concave on the outer $\frac{2}{3}$ to the turned up tips. Thus in the antero-posterior view of the Stornoway specimen the processes are stouter at the root than in the other two, are more compressed in the outer half than in the Wick specimen, are turned up at the tips, and are about an inch longer than in the other two specimens. A line between the middle of the outer parts of the transverse processes intersects the cup so as to cut off, in the Wick and Peterhead specimens, the upper 3 of the 11 inches, in the Stornoway specimen the upper 2 of the 10 inches, and intersects the base of the process, so that in the Peterhead specimen about 3 inches are above and a little more below, while in the Stornoway specimen about 3 inches are above and 5 below. The following are the height and girth at the middle of the transverse process in the three specimens—Wick, $4\frac{1}{2}$ and $11\frac{1}{2}$ inches; Stornoway, right $3\frac{1}{2}$ and $10\frac{1}{2}$, left 4 and $11\frac{1}{2}$; Peterhead, $2\frac{3}{4}$ and 10. The process in the Norway atlas is too much injured to admit of accurate conclusions being drawn.

Observed from above, differences are seen (see Figs 1, 2 and 3). At the back part of the root there is a rough tubercle (internal tubercle) from which a ridge passes obliquely across the process towards the fore part of the tip. This ridge is much more developed in the Wick specimen, rendering the process much less flat than in the Peterhead specimen. Another tubercle (external inter-transverse tubercle) is developed behind the tip in each, rendering the outer part, antero-posteriorly, an inch more than the inner part, and making the posterior margin internally much more concave than the anterior. The outer margin is convex in the Wick, nearly straight in the Peterhead specimen, and the extreme point in both is the anterior angle. In the Stornoway specimen the extreme point is the posterior angle, which is prolonged backwards and outwards, the outer margin rounding off to continuity with the anterior margin, giving the processes a backward droop externally. Farther, the surfaces of the process are much twisted beyond the root, so that the inferior surface looks obliquely forwards, the superior obliquely backwards, and the oblique ridge, noticed on the upper surface in the other two specimens, remains as the upper border of the twisted process[1]. In the Peterhead specimen the surfaces are directly up and down, superior flat, inferior convex; but in the Wick specimen, especially on the right side, an approach to the twisted form is seen, the increase downwards at the root giving the anterior surface some obliquity, and prolonging the inferior surface of the root outwards, so as to give the process a somewhat triangular figure. The differences in form between the transverse processes in the Peterhead and Stornoway specimens are certainly remarkable.

Seen in position, the processes stand nearly straight out in the Wick and Peterhead specimens, but in the Stornoway specimen they have a backward droop externally. The distance between the nearest part of the tips of the transverse processes of the atlas and the surface of the wing of the axis behind them is, in the Wick specimen 6 inches, Peterhead 5, Stornoway $2\frac{1}{2}$ to 3; the distance is nearly an inch less to the tubercle (inter-transverse) of the axis, in the Wick and Peterhead specimens, from its being turned forwards towards the atlas, while the little development of this tubercle in the Stornoway specimen is probably related to the unusual prolongation, above noticed,

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[1] This twist of the transverse process is an approach to the condition in the lesser Fin-whale, in which this character is strongly marked. The same obliquity may be seen in man and in various other mammals.

of the tip of the process of the atlas. The tips pass out beyond the foramen of the axis for an inch or more in the Peterhead and Wick, for about two inches in the Stornoway specimen. Their lower margins, except quite at the base, are nearly on a level with the upper edge of the foramen, except in the Stornoway specimen, in which they project down in front of the upper fourth of the foramen, and more internally towards the base.

(*f*) *Canal of the Atlas.* The constriction indicating the division into two parts varies. The width at the constriction in the several specimens is, Peterhead $1\frac{1}{4}$, Wick $2\frac{1}{8}$, Stornoway $2\frac{1}{4}$, Norway $2\frac{3}{4}$, but the appearance of constriction is most marked in the Stornoway specimen. The general form of the odontoid division of the canal is, in the Wick specimen, that of a blunt-pointed triangle with gently concave sides (greatest breadth $2\frac{3}{4}$); in the Stornoway specimen it is bulged at the sides and more pointed below (breadth 3); in the Norway specimen it is like the lower two-thirds of an ovoid (breadth 3); in the Peterhead specimen the ligaments still remain filling it up, but it most resembles the Wick specimen. The projection sustains, as in man, the most internally projecting part of the articular surface behind it, but more immediately attaches the upper part of the transverse ligament, the attachment of the ligament continuing down to where the opening begins to contract, leaving a triangular odontoid opening, bounded above by the concave edge of the ligament. The neural division of the canal varies a little in width in the different specimens (see table), and its form above is influenced by the curvature of the neural arch, which is less in the Norway specimen than the others, giving it more distinct upper lateral angles. The general form may be defined as square-shaped, with rounded angles, and contracting downwards, or as triangular with a very blunt apex below. Vertically, it measures about $4\frac{1}{2}$ inches to the concave edge of the ligament, $4\frac{1}{4}$ to the bony projections, which are situated below the middle of the general opening; its greatest breadth is about the same when taken anteriorly (as given in the table), but posteriorly the canal is much wider; near the intervertebral foramen in the Wick and Norway specimens it is 6 inches, in the Peterhead $5\frac{3}{4}$, in the Stornoway specimen $5\frac{1}{2}$.

(*g*) *Sub-axial process.* The peak on the hinder part of the atlas, the development of which has been regarded as a character of specific import, is present in various degrees in these specimens. The horse-shoe articular surface recedes here for $\frac{3}{4}$ inch in the Norway and Peterhead specimens, $1\frac{1}{2}$ in the Wick and Stornoway specimens, leaving a median triangular notch. The upper part of this notch is a rough depression, while from the lower part a pointed process projects more or less backwards. In the Peterhead specimen, though forming a projection from where it begins, it does not reach so far as the edge of the atlas itself; in the Stornoway specimen it projects half an inch behind the rest of the atlas and in below the axis, as a median conical process, occupying the whole height of the notch; in the Wick specimen it projects transversely, as a tongue-like process, from the lower part of the notch, $\frac{1}{2}$ inch in length, $2\frac{1}{2}$ inches in breadth, but, although larger than in the Stornoway specimen, it barely reaches to below the axis[1].

(B). IN THE LESSER FIN-WHALE[2] (B. Rostrata).

17. TRANSVERSE PROCESSES.—(*a*) *Completion of the rings.* It may be considered as determined that the various degrees of

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[1] This process is much more developed in a portion of the atlas of a great Finner in my possession, which came I believe from Orkney. It is a larger atlas than either of the above. The lateral portions have unfortunately been sawn off through the outer parts of the articular surfaces. It has the following dimensions. Greatest height, spine being away, $15\frac{3}{4}$ inches; height of canal $9\frac{1}{3}$; greatest width of canal, anteriorly $4\frac{3}{4}$, posteriorly $7\frac{1}{4}$; width at constriction $2\frac{7}{8}$; below this the canal slightly diminishes downwards to a very blunt rounded lower end. Length of articular cup, now $11\frac{1}{2}$, probably 12; breadth $6\frac{1}{4}$; median groove between cups very broad, narrowest (at an inch from lower end) $1\frac{1}{3}$, at middle $1\frac{3}{4}$, near canal $1\frac{7}{8}$. Transverse canal small, length $3\frac{1}{4}$; inner end oval antero-posteriorly, long axis scarcely $\frac{3}{4}$; outer end vertically oval, long axis $1\frac{1}{4}$; thickness of its bony roof $1\frac{1}{2}$. On posterior aspect, crescentic ligamentous surfaces scarcely $1\frac{1}{2}$ in breadth and moderately depressed; lateral articular surfaces, length $10\frac{3}{4}$, moderately convex, united in one great horse-shoe surface. *Sub-axial process* greatly developed, amount of projection as seen from above, 1 inch, from below $1\frac{3}{4}$ inch, breadth at base $5\frac{1}{2}$, rising gradually, greatest to right side; thickness $1\frac{1}{4}$, coming close up to horse-shoe surface, which is $3\frac{3}{4}$ inches in height at the middle line.

[2] These vertebrae in B. rostrata have been described in a nearly full-grown specimen by Prof. Flower (*On a Lesser Fin-Whale, recently stranded on the Norfolk coast:* Pro. Zoo. Soc. May, 1864), who has also given notices of specimens which he examined in the Museums of Leyden, Brussels and Louvain (*Notes on the Skeletons of Whales in the principal museums of Holland and Belgium*, P. Z. S. Nov. 1864); and by Drs Carte and Macalister of Dublin (*On the Anatomy of Balaenoptera rostrata*, Trans. Roy. Soc. 1868) in a young specimen nearly the same length as mine. Their various conditions of ossific

ossific development of the rings is a matter chiefly of age, partly of individual variation. In this $14\frac{1}{2}$ feet long specimen none of the rings are ossifically complete. That of the axis wants $\frac{3}{8}$ inch at the outer edge of the ring. The terminal plate of cartilage by which it is completed is only an inch in breadth, the ovoid ring almost two inches. In the fœtus, Eschricht found the 5th and 6th with complete rings; and Van Beneden and Gervais, speaking of B. musculus, remark: "On peut admettre que dans cette espèce, comme dans la *Balænoptera rostrata,* ces anneaux sont toujours complets, à l'état de cartilage, dans le jeune animal, et que les différences ne sont que le résultat d'une ossification plus ou moins complète." Drs Carte and Macalister mention "fibro-cartilage" as completing the rings in their young specimen, and in my notes of the dissection the completing structure has been recorded as ligamentous. The bony processes were succeeded by a cartilaginous stage, and this again by a fibrous stage, completing the canal. The cartilaginous stages varied in length; on the superior processes of the 4th and 5th they were $\frac{1}{8}$ inch; on the inferior processes of the 5th, the most ossified of all the inferior processes, they were on the left side $\frac{1}{2}$ inch, and $\frac{3}{4}$ inch on the less ossified right side. The ligamentous prolongations, beyond the cartilages, were quite distinct from each other for some distance, but, owing to the convergence of the processes, they became confluent at their outermost part, and could not be traced round to meet the corresponding process. This was more especially the case with the third, the fibrous part of which became intimately connected with the thick periosteum of the overlapping wing of the axis; and with the sixth, owing to the superior process of the 7th slanting forwards so much against it. Even the 4th and 5th could not be traced round, the fibrous part of the lower process of the 4th appearing to end on the (farther out) cartilage of the lower process of the 5th. The fibrous parts of the processes may be looked on as portions of that thick periosteum which encloses the bones

development are remarked on in the *Ostéographie des Cétacés*, of Van Beneden and Gervais, p. 160, and they are figured in Pl. 12 and 13 of that valuable work. Dr J. E. Gray has also figured some of them in P. Z. S., May, 1864, and in *Cat. Seals and Whales, Brit. Mus.* 1866. My remarks relate to some farther points in the osteology illustrated by this young specimen, and to the articulations.

and cartilages in the cetacea, from within which fœtal cartilage has been absorbed, or within which ossification is advancing.

The lower transverse process of the 7th vertebra was nearly altogether represented by a ligament, attached internally to a short pointed bony process (over ½ inch in length), externally to the cartilaginous tip of the superior process; the ligament 1¾ inches in length, and flattened in the same direction as the bony processes[1]. This fibrous representative of the inferior transverse processes of the 7th vertebra is serial with the ligaments sent in from the heads of the anterior ribs, and from the tips of the corresponding dorsal transverse processes, to the sides of the bodies of their vertebrae[2].

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[1] Prof. Turner found in the fœtus of one of the great Fin-whales (B. Sibbaldii) the inferior transverse processes represented by cartilage, completing a cartilaginous ring. See this *Journal*, 1871.

[2] These were examined on the three anterior dorsal segments, and are still seen on the dried preparation, and I may here note the arrangement. The 1st rib rested generally on a fibrous cushion interposed between it and the converged tips of the transverse processes, from the axis to the first dorsal, more precisely against the 7th cervical and 1st dorsal, but also on the 6th cervical (end of its lower transverse process), its chief ligamentous connection being with the 6th. From its short capitular process a ligament passed in to join the outer part of the ligamentous representative of the inferior transverse process of the 7th cervical vertebra, while from the tip of the 1st dorsal transverse process a separate ligament passed in to the body of the first dorsal vertebra, where it is attached to a conical bony parapophysis, like that on the 7th cervical. The 2nd rib, after being connected by a ligamentous cushion to the second dorsal transverse process, sends in a pretty long capitular process, going about half way in to the body, from which a strong ligament is prolonged to the 2nd and 3rd bodies, and to the fibro-cartilage between. The deeper part of this ligament is a prolongation from the second transverse process along the upper edge of the capitular process of the rib, so that the ligament passing in to the bodies is in its upper part parapophysial and in its lower part pleurapophysial. The 3rd rib repeats this, but having scarcely any capitular process, the two parts of the ligament are identified earlier. These parapophysial ligaments prolong the lower wall of the lateral canal of the neck backwards into the thorax.

In both of the great Fin-Whales this part was so mutilated, as it is very apt to be in dividing the carcase, that I could only infer the presence of a ligamentous representative of the inferior transverse process of the 7th cervical vertebra from portions which remained, showing a ligament as thick as two fingers laid together. From the dissection of the Peterhead Razorback I inferred that such a ligament, connected to the body of the seventh cervical vertebra, 7 to 9 inches of it remaining, had been connected externally to the movable capitular process of the first rib, and along it to the transverse process of the 7th cervical vertebra. These ligaments will vary with the extent to which the ribs develop capitular processes. I may note here that in the Stornoway Razorback the three anterior pairs of ribs all develop long capitular processes, and that if the movable capitular process which I figured on the first rib of the Peterhead Razorback (see this *Journal*, 1871) were ankylosed and a little enlarged, it would represent very well the form which both first ribs present in the Stornoway specimen. I was able to examine the connection of one of the first pair of ribs to the transverse processes in the Wick specimen. It rested in a socket on the transverse processes, formed in (*b*). The *bony inferior transverse processes* differ from those of the great Finner in being relatively stronger and in having a more downward direction. They are present as half-inch-long conical processes on the 7th cervical and 1st dorsal vertebrae. The tubercular stages of the next four (6th, 5th, 4th, 3rd) increase in length forwards to the 3rd, on which they are twice the length of those of the 6th, and are directed outwards and downwards, unbent, as far as their outer prominence, which is strongly marked. These processes, therefore, descend below the level of the bodies more than in the great Finner forming the sides of a sub-vertebral space, the depth of which at the 3rd is twice that at the 6th, while in the great Finner it may scarcely increase in depth forwards. The nerve-groove stage then turns upwards and outwards, tapering, and is variously ossified,—on the 6th full-length on the right side, half-length on the left; on the fifth, nearly full-length on the left, under two-thirds length on the right; on the 4th, just beginning on the left side, not begun on the right; on the 3rd the process continues robust to the end, no part of it turned up. The processes of the 4th are the most horizontal, those behind them inclining forwards. Those of the 4th and 3rd are not directed backwards, as they are in the great Finner by the greater slant of the wing of the axis, but slant a little forwards, that of the 3rd consequently coming very close to the wing of the axis, and it is the most robust of all the inferior transverse processes. The different states of the inferior transverse processes of the 6th vertebra in the two groups forms a marked contrast, the grooved stage being more or less unossified in the great Finners, while in this lesser Fin-whale this stage is better developed than in any of the other cervical vertebra, shooting out to near the end of the superior process of the 7th, the

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front by the 7th and partly by the 6th cervical, behind by the 1st dorsal. Its chief ligamentous connection was to the 7th cervical. Between the rib and the cervical part of its socket was a great fibrous cushion on which it rested, while between it and the dorsal part of the socket was a quasi-synovial cavity about 2 inches in diameter, with periosteal surfaces on the rib and on the first dorsal transverse process, the ligaments forming a kind of capsule around it. On the 2nd dorsal transverse process the attachment of the 2nd rib was indicated by a thick capsular cushion with central cavity bounded by soft irregular walls. No synovial cavity existed in connection with any of the ribs in the young Pike Whale, although the separation of the perichondrium is at first apt to deceive the dissector in regard to this.

two forming a strong arch for the support of the first rib. The *ligaments* between the inferior transverse processes (inter-parapophysial) are oblique in different directions; an external series running between the tubercles forwards and outwards, strongest behind; and an internal series, the largest, passing from the tubercles forwards and inwards, increasing forwards, and of great size between the 3rd and axis and between the axis and atlas.

(*c*) The *superior transverse processes* are well ossified; the 7th fully, like the first dorsal though not so robust; the 3rd, 4th, 5th and 6th, in their first two stages, of nearly equal length, and much more slender than the corresponding inferior processes. The distinction between the nerve-groove and the tubercular stages is marked on these four more distinctly than in the great Finner, by the presence here of a series of triangular processes directed forwards, between which the inner part of the superior inter-transverse ligaments passes. On the 7th cervical and 1st dorsal vertebrae these processes (meta-pophysial) are placed more internally, close to, or almost on, the anterior articular processes.

(*d*) The *lateral canal* formed by the rings of the transverse processes differs in this young lesser Fin-whale from that of the great Finner both in relative capacity and in form. Taken at the fourth vertebra, it is transversely less than half the breadth of the body, and its capacity is not much greater than that of the spinal canal, their circumferences being respectively 7 inches and 8. In form, instead of being transversely triangular or ovoid, it is vertically ovoid or rather semilunar, the blunt end downwards and outwards, owing to the more downward direction of the transverse processes, a line prolonged from the transverse axis of the bodies leaving a much larger proportion of the ring below than in the great Finner.

The neural arches are high and triangular, with rounded lateral angles. At the 4th, the breadth of the spinal canal is $2\frac{5}{8}$, the height $1\frac{11}{16}$. Below the 4th it increases in breadth and diminishes in height; at the third with about the same breadth as at the fourth the height is 2 inches; while at the axis the height and breadth are each $2\frac{1}{4}$. The laminae are thin on their anterior, thick on their posterior edges, overlapping a little but nowhere in contact. The spines are mere rudiments on the 3rd, 4th, and 5th, on the 6th half an inch in length, on the 7th longer.

18. BODIES AND THEIR FIBRO-CARTILAGES.—There was very little motion between the cervical vertebrae in any direction, the motion, small as it is, becoming more limited forwards. The rotatory motion taken at the zygomal processes was not over $\frac{1}{16}$ inch in extent. The thickness (length) of the fibro-cartilages, not including the rim of cartilage belonging to the epiphyses, was—behind 2nd dorsal, $\frac{1}{2}$ inch; behind 1st dorsal and 7th cervical, each $\frac{1}{4}$ inch; behind 6th, 5th, and 4th cervical, $\frac{1}{6}$th; behind 3rd, over $\frac{1}{8}$; behind 2nd, $\frac{1}{8}$ inch. The bodies of the 3rd, 4th, and 5th vertebrae are from $\frac{4}{8}$ to $\frac{5}{8}$ inch in thickness, those of the 6th and 7th are about $\frac{1}{8}$ inch more. When divided, the fibrous part was seen to reach half an inch inwards above, a little more below, dipping in to $\frac{3}{4}$ inch at the middle line above and below, the measurements of the body surfaces being,—breadth, at the third $4\frac{1}{8}$ inch, at the sixth $\frac{1}{4}$ inch less; height, at the third $2\frac{1}{2}$, at the sixth $\frac{1}{4}$ inch more. Before and behind the 3rd, although the pulp surfaces are as extensive as at the other spaces, there was very little pulp, owing to the nearness of this vertebra to those next it. The body surfaces are, especially in the transverse direction, a little convex in front, a little concave behind, better marked the farther forwards. The middle of the anterior surface of the bodies, corresponding to the centre of the pulp, is rough, rising into a faint prominence on the posterior vertebrae. The epiphyses want from $\frac{1}{8}$ to $\frac{1}{6}$ inch of reaching the edge of the bodies. The thinnest part of the body is at each side of the pulp space, so that, in the macerated bones, the sides of the bodies come in contact, leaving thin spaces between the surfaces, deepest at the middle line, both above and below; this being also due in part to the curvature of the bodies just mentioned.

19. ARTICULATIONS OF THE ATLAS AND AXIS.—(*a*) The *articular surfaces* are continuous across the middle line below, forming one great horse-shoe cartilaginous and synovial surface. There was a faint median depression in the cartilage, though no interruption to its continuity, and through the dried cartilage is now seen a median furrow on both bones, which in fully

macerated bones has led to the surfaces being reckoned distinct. The odontoid rises higher than in the Razorback and is at the same time broader and less abrupt, the whole area rising gently to a rounded prominence, the summit of which is near the upper part, towards the transverse ligament. (*b*) The *transverse ligament* (see Fig. 6) is, in this whale, flattened in the same direction as in man, but is somewhat prismatic; upper surface flat and a little concave transversely, forming part of the floor of the spinal canal, in line with' the body of the axis; anterior border thick; lower surface applied obliquely against the odontoid process, which in this whale rises a little above the level of the ligament. But the transverse ligament is not free; its hinder edge joins the periosteum on the upper surface of the axis, and its lower surface is attached to the odontoid as it crosses.

(*c*) The *check ligaments* (Atlo-odontoid) have essentially the same connections and function as I have described in the Razorback, but from the greater prominence of the odontoid, and the greater width of this division of the ring of the atlas, they are less interosseous in position, and their fibres have less of a forward direction. Its attachment on each side to the atlas is to the narrow crescentic surface between the posterior articular surface and the edge of the ring, meeting its fellow in the middle line below; while its upper fibres, attached inwardly to the upper aspect of the odontoid, outwardly to the atlas, are continuous with the deeper fibres of the transverse ligament, giving that ligament its connection to the odontoid. In the Razorback the lowness of the odontoid required these fibres to pass forwards some distance to reach the posterior surface of the transverse ligament; while here the transverse ligament is so close that, besides attaching ligamentous fibres from the odontoid, it gives direct support to that process, its surface being adapted accordingly. Concealing, from before, the lower part of the check ligaments, there is a fibrous structure like an *inferior transverse ligament*, embracing semicircularly the odontoid below as the transverse ligament does above. The deeper part of this inferior fibrous girdle is continuous with the lower part of the check ligaments, as the transverse ligament is with their upper part, and superficially it forms a fibrous cushion, levelling up the lower part of the odontoid division of the ring of the atlas and giving a soft flooring for the inner part of the occipital condyles, which here project inwards beyond the inner edge of the atlantal cups. Between these two fibrous girdles the odontoid is seen for a breadth of ¾ inch, with the remains of the ligamentum suspensorium attached to it.

(*d*) I was able to examine the *superficial ligaments* between the atlas and axis more satisfactorily here than in the great Finner in which they had been injured. Below, besides the inferior longitudinal ligament of the bodies, a strong inferior oblique ligament, serial with the inferior inter-transverse ligaments but much stronger, passed inwards and forwards to the atlas from the transverse process of the axis. There was a well marked capsular ligament round the outer side of the articular surfaces, also well marked on the inner side of these surfaces, above the position of the transverse ligament, but below this identified with the check ligaments. Above, besides the interspinous ligament, the interlaminar ligament was a strong membrane, leaving between it and the upper end of the articular surfaces a space for the passage of the second nerve; and a strong ligament (superior inter-transverse) passed from the upper transverse process of the axis to the transverse process of the atlas, serial with the superior inter-transverse ligaments behind. On either side of this ligament was a space from which the contents had been removed, apparently the spaces through which the superior and inferior divisions of the second nerve had passed.

Notwithstanding the extent of the synovial articular surfaces between them, the *motions* of the atlas on the axis were very limited. Vertical and lateral gliding motions were not over $\frac{1}{20}$ inch in extent. Rotatory motion was checked before the tip of the transverse process (which is 4 inches from the centre of rotation) had moved ⅛ inch. All the external ligaments help to check, but after their division the rotatory motion remained as limited in extent as before, and as long as the check ligaments were undivided the atlas could not be lifted $\frac{1}{20}$ inch off the axis. These extensive synovial surfaces, usually in other animals an adaptation to extensive motion, must, therefore, be regarded as rudimentary here, so far as their synovial condition is concerned. The amount of yielding and elasticity is not greater than that which fibro-cartilages allow, and their retentive power is inferior.

20. Occipito-atlantal Surfaces.—On applying the atlas on the occipital condyles, the lower end of the condyle is seen to project about an inch ($\frac{1}{5}$ part of the whole length) below the cup, and this part of the condyle is more abruptly curved. The atlantal cups are seen to project a little laterally beyond the condyles, while the condyles approach each other internal to the cups, so that over half an inch of the breadth of each condyle is seen through the odontoid division of the ring of the atlas. The distance to be traversed by the ligamentum suspensorium, from the odontoid to the fissure in the floor of the inter-condyloid fossa, does not exceed half an inch. The neural division of the canal of the atlas corresponds in form to the foramen magnum but is somewhat larger, being transversely nearly $2\frac{5}{8}$, vertically $1\frac{7}{8}$, while the foramen magnum measures transversely $2\frac{3}{8}$, vertically $1\frac{6}{8}$. The odontoid division of the canal is relatively much wider than in the great Finner, measuring transversely at its widest part near the transverse ligament $1\frac{6}{8}$, vertically $1\frac{2}{8}$ inch; total height of canal of atlas $3\frac{2}{8}$. The position of the transverse ligament is a little below where the distinction of the two parts of the canal appears on the bone. The transverse foramen for the atlantal nerve, between the lamina and the upper end of the cup, is completed by bone on both sides, and is about the size of a goose-quill.

21. Explanation of the Drawings. Plates I and II.—The drawings are from photographs kindly taken by my pupil, Mr J. Shearer. The outlines taken from these were carefully filled in and shaded from nature, in my presence, by Mr Gibb. In taking the first three views the vertebrae, built up on the table, were separated to the extent to which they are naturally separated by their fibro-cartilages. The two front views are placed above and below for more ready comparison.

Fig. 1. Under-aspect of the cervical vertebrae of the *Peterhead* Razorback. The distinction between the tubercular and nerve-groove stages of the inferior transverse processes is well marked. It shows a deep atlo-axoid articulation ; greater length of the left than of the

right wing of the axis; a great development of the tubercular stage of the inferior transverse process of the 3rd; a nearly symmetrical deficiency at the nerve-groove stage of the inferior transverse processes of the 6th; traces of the posterior body epiphyses of the 6th and 7th vertebrae, indicating that the animal, though of full length, was not quite mature; &c.

Fig. 2. Under aspect of the cervical vertebrae of the *Stornoway* Razorback. Comparing this fig. with Fig. 1, it shows a different form of transverse processes of atlas; a shallow atlo-axoid articulation; a more projecting sub-central process of atlas; the wings of the axis greatly developed, backwards to the level of the tip of the transverse processes of the 7th, and also downwards so as to show part of the surface of the wing, while in Fig. 1 only the border is seen. The undulations of the wing are seen, the internal eminence, opposite the tip of the transverse process of the atlas, is just external to the ring. The rudimentary state of the inferior transverse processes of the 6th, although it was a mature animal, will be observed; also the distinction between the tubercular and nerve-groove stages on the inferior processes of the 3rd, 4th, and 5th vertebrae, though not so strongly marked as in Fig. 1; and the transverse process of the 5th is seen to be horizontal, and, after that of the axis, the longest and the most projecting.

Fig. 3. Upper aspect of the cervical vertebrae of the *Wick* Razorback. On the atlas is seen the oblique ridge roofing the foramen in front, and supporting an articular process behind; the two grooves proceeding from the foramen; and some a-symmetry of the transverse processes. The axis shows great development of the crests in the region of the spine (still more developed in the Peterhead specimen), the right crest articulating with the atlas. On the wings, opposite the tip of the transverse process of the atlas, is seen the strongly marked and turned forward inter-transverse tubercle, and, bounding the concavity external to it, the upper angle of the wing, farther out on the right than on the left side in this specimen. The superior transverse processes appear thin at their inner third (nerve-groove stage) from the direction of their surfaces, and external to this (tubercular stage) are seen to be bevelled and rough, and to begin to overlap. The inferior processes are seen in deep shading beyond, that of the 3rd of great size on the left side, that of the 6th complete on the left side, and partly deficient on the right. On the laminae of the five posterior vertebrae are seen the very rudimentary spines; the more developed anapophysial processes, serial with the crests of the axis; and the partially cribriform condition of some of the laminae from their extreme thinness near their anterior margins, in this mature or aged animal.

Fig. 4. Front view of *fifth* cervical vertebra of the Stornoway Razorback. On the body, externally, is seen the streaked ring where the capsular part of the fibro-cartilage is attached, and within this the figure-of-8 surface where the pulp lies, somewhat raised at the

middle. The laminae show, about the middle, a non-symmetrical anapophysial process; the spinal canal is intermediate between the triangular form presented by the Peterhead specimen, and the elliptical form presented by the Wick specimen. Spine also intermediate in length. On the lower transverse process (*a*) is the root stage; (*b*) the tubercular stage, with its outer and inner angular prominences; (*c*) the nerve-groove stage, the groove seen to be directed obliquely outwards and downwards. On the upper processes, (*d*) is the nerve-groove stage. At the inner part of this a small tubercle is seen (as it so happens, unusually developed on the left side of this vertebra) on the upper edge, the grooving being on the surfaces; (*e*) is the tubercular stage, marked off from the nerve-groove stage by an angular elevation, but the tubercular character of this stage, owing to the bevelling, is visible only in an upper view (see Fig. 3); (*f*) is the third stage of the superior process, the terminal plate, developed in the mature animal. It is seen to be less developed on the right side, the upper angle not having been yet formed. The rings in this specimen present the semi-oval form.

Fig. 5. Hinder aspect of the atlas of the Wick Razorback. The transverse ligament (*a*), flattened in the opposite direction to that of man, is seen dividing the canal into an upper or neural division, and a lower, odontoid or ligamentous division. On each side of the lower division is seen the crescentic surface where the atlo-odontoid check ligament is attached, unsymmetrical in this specimen. The articular facet, by which it articulates with the right crest of the axis, is seen on the right lamina above the groove for the nerve-escape. The internal inter-transverse tubercle, at the upper edge of the root of the transverse process, is seen to be more developed on the left side, and the external tubercle, behind the tip of the process, to be also unsymmetrical. A median groove is seen dividing the articular surface into two, but the two are naturally continuous, the presence of the groove being exceptional in this specimen.

Fig. 6. Front aspect of atlas of young (14½ feet long) Pike Whale (B. rostrata). Transverse ligament (*a*) not flattened as in the Great Finner, but prismatic. Both upper and odontoid divisions of canal are proportionately wider than in the Great Finner. Median groove seen between condyloid cups, where ligamentous septum is attached. Transverse foramen for atlantal nerve already roofed over. Transverse processes incompletely ossified, but the twist is seen.

NOTICE OF QUADRUPLE MAMMÆ, — THE LOWER TWO RUDIMENTARY, — IN TWO ADULT BROTHERS. By P. D. HANDYSIDE, M.D., F.R.S.E., *Teacher of Anatomy, Edinburgh School of Medicine.* (Plate 3.)

ONE of my pupils,—say A. B.,—20 years of age, 6 feet ½ inch in height, of active habits, lean but muscular, well-formed and healthy, presented himself to me in February, 1872, having four mammæ on his chest, the two lower of these being rudimentary (Fig. 1). He is the eldest of a family consisting of five males, and was a forceps-infant in the hands of Dr Hewit of Lauder. The *Mammæ Proper* are normally situated, are exactly four inches distant from the mesial line, and are more fully developed than usual. The *right* mamma is seven-eighths of an inch in its long axis, which runs downwards and outwards, and six-eighths of an inch vertically; around its prominent and rose-tinted mammilla two concentric rugæ appear, and on the inner and upper half of the periphery of a dark areola are seven prominent papillæ (Fig. 2). The *left* mamma is also seven-eighths of an inch in its long axis, which likewise runs downwards and outwards, but it is only five-eighths of an inch in extent vertically; it also presents two nearly concentric rugæ, and on the upper and outer two-thirds of its pale areola are one or two less prominent papillæ (Fig. 3). The *Lower Mammæ* are situated exactly three inches from the mesial line. The *right*, however, is 2¾ inches below the right mamma proper, and 8½ inches from the umbilicus, while the left is placed 3 inches below the left mamma proper, and 8⅛ inches distant from the umbilicus. Again, the right lower mamma is ovate in form, with its base towards the umbilicus; its long axis is, therefore, downwards and inwards, and in length is one-quarter of an inch; its vertical axis being one-eighth of an inch. Its mammilla is one line in diameter, round in form, and bilobed; the septum between the adherent elliptical lobes or nipples running in the long axis of the areola. This areola is of a light pink colour, and consists of thin delicate skin (Fig. 4). The *left* lower mamma is elliptical in shape, with its long axis placed transversely. Its long axis is a quarter of an inch, while its vertical or short axis is one-eighth of an inch, in extent. The mammilla consists of two distinct elliptical elevations, which lie parallel to each other, and in the long axis of its areola, and these elevations or nipples are each of one line in length and half-a-line in breadth (Fig. 5). In A. B.'s figure the distance from the scrobiculus cordis to the umbilicus is 7½ inches, while that from the umbilicus to the root of the penis is seven inches The *umbilical cicatrice* is elongated transversely, and unequally bilobed, and there is a trace of double *linea alba* below the *præcordia.* His *genital organs* are fully developed and natural. At puberty his *mammæ proper* enlarged to an unusual size.

In the second son of this family, 18 years of age, the mammæ at puberty were so much developed, and discharged the usual milky fluid so freely, that "Dr Turnbull of Dunbar," as I am informed by letter, "had to employ means to reduce them sufficiently to prevent their forming an impediment in his examination on entering the navy."

The third son of the same family,—say C. D.,—who is 17 years of age, and five feet ten inches in height, has also QUADRUPLE MAMMÆ. The *mammæ proper* are placed as usual, but are more fully developed. They are situated 8½ inches apart. The *lower* or rudimentary mammæ are 7½ inches apart. The right lower is placed 2½ inches below the upper right mamma, and 8½ inches from the umbilicus; while the left lower is 3 inches below the upper left mamma and 8 inches distant from the umbilicus. This left supernumerary mamma is distinctly marked, but the opposite right one is merely indicated by a white puckered spot of skin.

No similar abnormality is known to have existed in their parents' family on either side. The mother of these young men is 5 feet 4 inches in height, of a delicate habit of body, and all her five infants were nursed on cows' milk alone. Their father, aged 62, is in height 6 feet 1 inch, and belongs to a long-lived family of from 70 to 80 years. He writes to me that all his "five sons have so far proved themselves to be big, strong, muscular and masculine, far beyond their years, that there is the very opposite of any evidence of the blending of the sexes in their case, and that on the contrary they are masculine to a degree." He goes on to say—what may not be irrelevant to the matter in hand—"my grandfather used to narrate to me a tradition of a notable ancestor, a man of unusual strength of body and an armourer by trade, who resided near Glammis in Forfarshire, and was said to be double-jointed in all his members, and to have forged Wallace's sword. He is understood to have formed the type of 'Hall o' the Wynd' in Scott's *Fair Maid of Perth*." Farther, in morphological connection with the question, it may be added, firstly, that varicocele exists in the second son, in his father, and also in his paternal uncle, and existed in his grandfather and his great-grandfather; and secondly, that no twin births are known to have occurred in this family on either side.

REMARKS.

(1) *Are these elevated spots mammæ?* Truly such a doubt no unprofessional eye has even suggested, and a mere professional glance, or that with a lens of low power, reveals distinctly characteristic areolas, well-marked cutaneous glands, and tubercles, and nipples. Did opportunity offer, a mercurial injection would probably flow along as in the male mamma generally. These observations apply, possibly with greater force, to the well-defined structures and parts so carefully marked by Dr Arthur Mitchell in a case of quadruple mammæ, which I now proceed to notice.

(2) *Parallel case.* I cannot trace on record an instance of a supernumerary Mamma, Areola, Tubercle, or Nipple in the male; but in notes that I took on Sept. 18, 1872, of a conversation that I then held with Dr Arthur Mitchell on the case of A. B., he stated that some years previously, while in Glen-Urquhart, Inverness-shire, he came upon a farm-servant, a male, about 27 years of age, who had just sustained contusions from a fall; in examining whose chest, Dr M. observed *four mammæ*, the *two lower* less developed than the upper, situated about a hand's-breadth from them, and equally distant with them from the mesial line. *The upper* mammæ were normal. *The lower* were less prominent; they presented faint areolas, and the

usual tubercles were as faintly marked; but they presented well-marked nipples. The man was stalwart, handsome, and of a muscular frame; he was well bearded, had testes and a manly voice. He was well-conditioned mentally. No similar abnormality, and no supernumerary digits or other malformation, had existed in his family, so far as could be learnt. Dr Mitchell communicated these particulars to me from memory, but was satisfied as to their substantial accuracy. Very shortly after the case came under his observation, he spoke of it to Professor Turner, through whom I was led to apply to him.

(3) *Blending of the sexual features.* There is a slight approximation to the female proportions in the position of the umbilicus in A. B.'s figure; for, whereas the usual proportional distance *in the male sex* between the præcordia and the umbilicus is one-fifth longer than that between the umbilicus and the root of the penis, and *in the female* the space between the præcordia and the umbilicus is one-fourth shorter than it is between the umbilicus and the base of the mons,—we have seen that in the case before us, the distance between the præcordia and the umbilicus is only one-fifteenth greater than is the distance between the umbilicus and the root of the penis.

(4) Since it is admitted, as *a teratological law,* that like parts of two unequal bodies, the autosite and the parasite, are always attached near one another, it may be well, in examining the question of *arrested twin development,* not to exclude from consideration such cases of supernumerary mammæ; and the peculiarity in the form of *the umbilicus* in A. B. may not be overlooked in connection with this remark.

CONTRIBUTIONS TO THE ANATOMY OF THE INDIAN ELEPHANT (ELEPHAS INDICUS), PART II. URINARY AND GENERATIVE ORGANS[1]. By M. WATSON, M.D., *Demonstrator of Anatomy in the University of Edinburgh.* (Plate 4.)

ALTHOUGH the urinary and generative organs of the Indian elephant have been described by various authors who have examined them in whole or in part, yet these descriptions differ so much from one another that it may not be altogether superfluous to put on record the results of my own observations on these parts of the animal, more especially as there is no systematic account of them to which the exclusively English reader can refer.

I shall in the first place consider the urinary and in the second the generative organs, comparing the observations of different authors as we proceed.

For the opportunity of dissecting these parts I have again to express my thanks to Prof. Turner.

URINARY ORGANS.

Kidney. This viscus measures one foot in length and seven inches in greatest breadth, thus differing materially in size from that examined by Stukeley[2], which measured three feet in length: his measurement, however, I cannot avoid thinking, has been somewhat exaggerated. It is triangular in form, tapering toward the anterior, but thick and rounded at the posterior extremity. Its outer border is uniformly convex, except where it is interrupted by lines indicating the subdivision of the organ into lobes. The inner border is also convex, but presents about its centre a deep concavity—the hilus—for the entrance of the renal vessels and duct. These occupy the usual relative positions, the ureter being situated dorsally, the vein ventrally, and the artery between the two. The capsule, which is strong and composed of dense fibrous tissue, adheres so closely

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[1] Part I. On the Thoracic Viscera, appeared in this *Journal*, November, 1871.

[2] *Essay towards the Anatomy of the Elephant*, Lond. 1723.

to the kidney as to allow of its subdivision into lobes being seen externally; it is however readily separable from the contained organ. On separating the capsule many vessels of large size are to be seen passing from the substance of the kidney into and through the capsule, demonstrating in this animal perforating arteries which in all probability communicated with the parietal branches of the abdominal aorta in a manner similar to that described by Prof. Turner[1] in the human subject. With reference to the number of lobes of the kidney, Camper[2] states that there are eight or nine, Cuvier[3] reduces the number to four, whilst Mayer[4] observes that it is composed of only two principal lobes. Dönitz[5] ascertained the number to be ten in that of the African elephant. In my own specimen the number of lobes in the left kidney was five, and these could be readily separated from one another without any laceration of the renal tissue. The number in the right kidney was unfortunately not observed in the same satisfactory manner, but, judging from the primary divisions of the ureter, which in the left kidney corresponded in number to the lobes, there would be four. On the surfaces of both kidneys, moreover, indications of a farther subdivision into smaller lobes were observed, but these were not traceable to any depth without rupture of the renal substance. It is however probable, I think, that these lines of separation indicate the subdivision of the kidney into lobes in the young animal, and that they become less and less distinct as the animal grows, and may finally be obliterated altogether. That the lobes are originally distinct, as in many animals, is proved by Camper's[6] dissection of a young specimen, in which he found that the lobes were only beginning to unite toward the exterior of the organ, their inner or apical extremities being altogether free. If this view be correct, it will explain the diversity of statement of different authors with regard to the number of the lobes.

Each of these lobes is to be regarded as a renal organ

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[1] *Brit. and For. Med.-Chir. Rev.* July, 1863.

[2] *Description anatomique d'un éléphant mâle.*

[3] *Leçons d'anatomie comparée*, Paris, 1805.

[4] *Nova acta acad. Cæs. Leo. Car.* XXII.

[5] *Reichert und Du Bois-Reymond's Archiv*, 1872, p. 85.

[6] *Description anatomique d'un éléphant mâle.*

complete in itself, possessing as it does a perfect system of tubes which do not intermingle with those of the neighbouring lobes. The kidney of the elephant thus presents an approach in structure to that of the cetacea and other aquatic mammals, differing however in this, that whilst in the latter the lobes are permanently distinct, in the former they are distinct during youth, but become more intimately blended as the animal attains maturity. With reference to the more minute structure, Cuvier states that there is no distinct line of separation between the cortical and medullary substances, while on the other hand Dönitz found the distinction between them as well marked as in the majority of animals. My own observations agree with those of Cuvier, at the same time it must be borne in mind that these kidneys had been subjected to the action of spirit for some time, which may have rendered the distinction between the substances less apparent to the naked eye than would otherwise have been the case. The tubes of Bellini do not terminate on papillæ as asserted by Cuvier, Mayer, Hunter[1] and Owen[2], but upon the flattened truncated extremities of the calyces in a manner which will be more particularly referred to along with the ureter.

The renal artery divides into three main trunks, each of which again subdivides into numerous branches, which enter the substance of the kidney. Before dividing, the trunk of the renal artery, as observed by Camper, gives off the spermatic artery to the testicle—an arrangement by no means uncommon in the human subject. The veins passing from the kidney are five in number, but whether they terminate in a common trunk or open separately into the posterior cava, could not be determined by reason of the organs having been removed from the abdomen. The calyces differ in number in the two kidneys, ten in the right, and thirteen in the left. It would thus appear that the number of calyces bears no constant ratio to that of the lobes, some of these being provided with two, and others with three calyces. The calyces are in the form of flattened tubes, terminating in a truncated flattened extremity, in the centre of which is to be observed a single aperture of large size.

[1] *Essays and Observations*, by Owen.
[2] *Anatomy of Vertebrates*, III.

On slitting open this aperture, it is seen to lead into a cribriform vault, the cribriform appearance of which is due to the openings of the tubules of Bellini. According to Dönitz, in the kidney of the African elephant, the aperture just described leads into an elongated central canal—the tubus maximus of Hyrtl[1], along the course of which the tubules of Bellini open: but in that of the Indian elephant this is not the case, as the central tubules of each calyx are prolonged downwards so far as to be little shorter than those of the periphery, which gives rise to the appearance of a shallow vault rather than to that of an elongated central canal such as is figured by Dönitz.

With the exception of Camper, as already stated, all the older writers have been deceived as to the existence of papillæ in the kidney of the elephant.

According to Cuvier and Mayer the ureter is formed by the union of three principal tubes. In the present specimen the ureter of the right side is formed by the junction of four and that of the left by five. In both kidneys these tubes emerge separately from the hilus. In the case of the right kidney the two anterior tubes unite to form one half of the ureter, the second half being formed by the junction of the two posterior tubes; whilst in the left kidney the one half is formed by the junction of the three anterior, and the second half by the junction of the two posterior. As regards the number of calyces opening into each of these tubes, enumerating them from before backwards, we find that in the right kidney the first receives two, the second two, the third three, and the fourth three, in all ten; in the left kidney the first receives two, the second two, the third three, the fourth three, and the fifth three, in all thirteen. The want of symmetry as regards the number of these tubes in the kidneys of opposite sides seems to indicate that this is not constant, which would account for the difference between my own observations and those of the authors already quoted.

There is, as stated by Cuvier[2], no pelvis properly so called, the tubes simply uniting without marked dilatation to form the ureter. This tube passes backwards so as to reach the posterior

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[1] *Denk. der Acad. der Wissenschf.* Wien xxxi. 1872.

[2] *Leçons d'anatomie comparée.*

wall of the bladder, being invested on its under surface by peritoneum; as it passes between the bladder and rectum, it lies directly above the corresponding vas deferens. Having reached the back of the bladder, the two ureters are separated from one another by a distance of 3½ inches. They then pass obliquely through the wall of this viscus for a distance of 2¾ inches, and open close together near the neck of the bladder. The very oblique and lengthened course of these tubes through the wall must form a thoroughly effective valve against the backward passage of the urine.

Bladder. This viscus is by no means so large as one would expect in an animal of such size. It is regularly oval in form, and occupies the usual position. Above it is the rectum, the vesiculæ seminales, and vasa deferentia intervening, whilst at the neck are to be observed the small prostatic glands, two in number on each side. The whole of the bladder, with the exception of the triangular interval, indicated by the points of contact of the ureters with the exterior of the bladder and the neck of the viscus, is completely invested by peritoneum, this investment on the lower aspect reaching as far back as the commencement of the urethra. The peritoneum covering the bladder presents moreover three well-marked folds or ligaments. Of these, one passes off from the inferior aspect of the viscus, and seems to correspond to that described by Camper[1] as attaching the bladder to the pubis. The author just mentioned observed in it the urachus, but no remnant of that structure could be discovered in the specimen under description, its absence being in all probability due to the age of the animal. The other two folds pass off from the lateral aspects of the bladder, and like the lower fold, each is composed of a double layer of peritoneum, and encloses, moreover, an artery which was still pervious in certain parts of its course. This artery is probably the hypogastric, but neither this nor the points of attachment of the peritoneal folds to the abdominal wall could be accurately ascertained, the parts having been removed from the pelvis.

On slitting open the bladder, the apparent thickness of its wall is seen to be due rather to the peritoneum, and sub-

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[1] *Description anatomique d'un éléphant mâle.*

peritoneal connective tissue, than to the proper muscular coat. The mucous membrane is uniformly smooth, and is not thrown into folds, except at the neck of the viscus, where it forms a single median fold of large size, which, commencing between the openings of the ureters, passes forwards to terminate on the floor of the urethra close to the base of the veru-montanum.

GENERATIVE ORGANS.

Testicle. This organ, which is almost globular in form, lies as figured by Camper[1] inferior to the posterior extremity of the kidney. It is entirely invested by peritoneum, with the exception of its upper and external margin where the vessels enter. The peritoneum, when traced outward, is seen to be reflected from the surface of the testicle, and to pass between it and the epididymis, the lower surface of which it also covers. The manner in which the peritoneum attaches the testicle to the posterior extremity of the kidney, notwithstanding that it permits of a slight degree of mobility of the former, altogether negatives the suggestion of Mayer[2], that this organ descends to the perineum during the period of rut. The epididymis lies along the outer side of the testicle and not the inner, as stated by some authors.

The spermatic artery, as before said, is given off from the trunk of the renal, it passes backward, and after a short course divides into four or five branches, which supply the organ. It gives, moreover, several branches of small size to the epididymis. The testicle also receives some branches of small size from arteries situated in front of it, but the exact origins of these could not be ascertained.

The veins leaving the testicle are remarkable for their number and large size. They are seven or eight in number, and communicate freely with one another, as also with neighbouring veins, so as to form a plexus close to the testicle. They finally unite to form two large trunks which open into the vena cava on the right side. The valves are very numerous in the veins composing this plexus.

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[1] *Description anatomique d'un éléphant mâle.*

[2] *Nova acta Acad. Cæs. Leo. Car.* XXII.

Several nerves of large size pass to the testicle along with the vessels.

The excretory ducts of the testicle (vasa efferentia) are ten or twelve in number, they pass off from the anterior extremity of the hilus of the testicle, and diverging as they pass outwards, enter the epididymis. With regard to the extent of this structure, it is impossible to say where it terminates, or where the vas deferens begins, as the vas does not form a flexure upon the epididymis as in those animals in which the testicle descends into a scrotum, but is simply continuous without interruption with the epididymis. The anterior extremity of the epididymis (Globus major) is the widest part, and on tracing it back we find that the size of its loops gradually decreases, so as to become continuous with those of the vas.

As regards this tube, with the exception of 5 inches previous to its termination, it is seen to be convoluted in the whole of its course. Its central portion is less convoluted than either of its extremities, and the anterior less so than the posterior; the latter extending from the peritoneal fold which unites the vasa of opposite sides down to the point where it becomes quite straight, being in fact so extremely convoluted as to resemble rather a second vesicula seminalis, than a portion of the vas deferens. Throughout the whole of this part of its course each vas is attached to the superior abdominal wall by a double fold of peritoneum, which forms as it were a ligament for it. The ligaments of opposite sides become continuous with one another between the bladder and rectum, and thus form a fold corresponding in position to the broad ligament of the uterus in the female. The vesicula prostatica, however, does not extend into this fold, as it does in the goat, ass, &c. With reference to the straight or terminal part of its course, each vas lies between the corresponding vesicula and the upper surface of the bladder, and before opening into the urethra dilates abruptly into an ampulla two inches in length, which is closely connected to its fellow of the opposite side. Finally, the vas unites with the efferent duct of the corresponding vesicula, the common ejaculatory duct thus formed opening into the urethra.

Whilst Cuvier's observations on these parts agree with my own, Owen, on the other hand, states that after dilating into the ampullæ, the vasa open "into the urethra distinctly from the vesicular glands."

Vesiculæ seminales.—These have been figured by Camper, and described by Cuvier. By the other writers on the elephant they are omitted. Each vesicula is an elongated sac six inches in length and one inch and a half in diameter, and occupies the interval between the bladder and rectum, being separated from the former by the ampulla of the corresponding vas deferens. Its inner surface is in contact throughout with that of the opposite side, whilst its base comes into relation with the peritoneal fold connecting the vasa deferentia. Each is invested by a thick layer of muscular fibre, which is continuous with that surrounding the membranous part of the urethra, the fibres diverging from their urethral extremities, so as to enclose each vesicula in a complete capsule. On slitting open the vesicula it is seen to be lined by a thick membrane, which is thrown into decussating folds throughout the greater part of its interior, so as to give rise to an appearance resembling the interior of the ventricles of the human heart. Towards the urethral extremity of the sac, however, these folds become parallel and uniformly longitudinal in direction. A transverse fold of large size separates the base of each from the body of the sac, and so gives rise to an appearance of two compartments, as described by Cuvier. Each vesicula terminates in a duct, which unites with the lower end of the corresponding vas to form the common ejaculatory duct, and finally opens on the side of the veru-montanum, and outside of the vesicula prostatica.

Prostate Glands. These little glands seem to have been observed by Duvernoi[1], although he was not aware of their nature, for he appears to have been of opinion that the prostate in the elephant is represented by what is now known to be Cowper's glands. Camper states that this gland in the elephant is the same as in other animals, but his figure is quite incorrect. Cuvier, however, describes them with tolerable accuracy.

They are four in number, two on each side, and of small size. They are placed below, and somewhat to the outer side

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[1] *Comm. Acad. scient. Petropol.* tom. II.

of the urethral extremities of the seminal vesicles, those of each side being closely applied to one another. In form they are oval, and the external one is the larger. It measures two inches in length, and one in greatest breadth, whilst the smaller or internal one is 1½ inch in length, and half an inch in greatest breadth. They are invested with a layer of muscular fibre continuous with that which surrounds the seminal vesicles. On slitting them open each is seen to contain a central cavity of an oval form, lined with a membrane, which is thrown into well marked longitudinal folds, which converge toward the urethral extremity of the gland. From this extremity the duct of each, which is single, passes off to open into a depression on the floor of the urethra, on either side of the veru-montanum, the openings of the ducts of each side being close together. In consequence of the glands themselves being situated at some distance behind the point where the ducts open into the urethra, each of these runs in the wall of the urethra for a distance of an inch and a half.

Cowper's Glands. Cuvier is the only author who describes these with any degree of accuracy. Camper states that they are present, but gives neither description nor figure, whilst Duvernoi mentions a *single* gland of the size of a large apple, which, so far as one can make out from his description, evidently corresponds to one of Cowper's glands, although he himself is inclined to regard it as the prostate.

The glands, as usual, are two in number. They lie one on either side of the middle line of the perineum, and under cover of one of the perineal muscles, to be subsequently described. Each is oval in form, somewhat flattened, and measures 2½ inches in length, and 2 in greatest breadth. They are therefore of large size as compared with the prostates. As regards their structure each is composed of a number of cells or lacunæ communicating freely with one another; but no separation of the gland into two distinct portions with corresponding cavities, as described by Cuvier, could be made out. At the same time it is possible that the length of time the parts had been subjected to the action of spirit may have tended to obliterate these cavities. From the anterior extremity of the gland a single duct measuring 3 inches in length, and sufficiently large to admit of the passage of a crow-quill, passes off, and, running for the anterior two-thirds of its extent through the spongy substance of the urethral bulbs, opens finally into the floor of the bulbous portion of the urethra by a valvular orifice. The orifices of opposite sides are separated by a distance of half an inch.

Cuvier states that each duct is formed by the junction of two smaller ones coming from the two portions of the gland above mentioned, but this arrangement cannot be traced in the present dissection. In addition to the perineal muscle concealing this gland and corresponding to the transverse muscle of Duvernoi, this author mentions another as being divisible into three distinct portions, and forming a capsule to the gland. This I failed to perceive.

Urethra. The membranous portion of this tube measures 8 inches in length from the neck of the bladder to the bulb of the urethra. It is invested by a continuous layer one quarter of an inch in thickness of transversely arranged muscular fibres. Passing backward toward the neck of the bladder, these fibres are seen to become oblique in direction, and continuous with those which invest the prostate glands and the seminal vesicles. In addition to this layer of muscular fibres this portion of the urethra is surrounded by an investment of cellular erectile tissue, continuous in front with the spongy tissue of the bulb of the urethra, and measuring an inch in thickness in transverse section in front, but thinning off gradually toward the neck of the bladder.

On opening this part of the urethra a median elevation is observed on the floor, projecting from the point where the fold of mucous membrane described in connection with the neck of the bladder subsides, and to slope obliquely forward and upward, terminating in the margin of the vesicula prostatica. This margin is circular in form, and the vesicula itself forms *a cul-de-sac* extending to the depth of a quarter of an inch in the substance of the veru-montanum. It will be observed, therefore, that it does not extend into the peritoneal fold connecting the posterior extremities of the vasa deferentia, as in many animals, but forms a mere shallow *cul-de-sac,* as in the cetacea. On each side of the veru is the slit-like orifice of the common ejaculatory duct. A well-marked fold of mucous membrane extends from either side of the veru-montanum obliquely forward and outward, and in the angle between this fold and the veru are to be observed the openings of the prostatic ducts—two in number on each side. On the floor of the urethra, in front of the veru, are two small orifices, resembling the openings of small glands, but no such structures could be discovered in connection with them. The spongy portion of the urethra presents nothing worthy of note.

The *muscles of the penis* are four in number on each side, three of these being situated on the lower aspect of the organ, and one, the levator, on the upper: 1st, The *Levatores penis* have been described by Duvernoi and Cuvier, and figured by Camper. They do not arise, as stated by the two latter authors, from the pubis, but from the upper and lateral aspect of each corpus cavernosum, close to its attachment to the ischium, as well as, and principally from, the tuberosity of that bone. Each is a powerful muscle measuring 4 inches in breadth at its origin, where it rests upon the dorsal vessels and nerves of the penis, but narrows rapidly to its extremity, where it ends on a thick rounded tendon. This tendon unites with the corresponding structure of the opposite side at the junction of the posterior and middle thirds of the penis, the two together forming a single median tendon common to the two muscles, which is inserted, according to Camper, into the glans penis. As regards this point, however, I could not satisfy myself, as that portion of the organ was reserved as a Museum preparation. The common tendon as it passes along the dorsum is confined within a strong aponeurotic sheath, which is continuous with, and formed by, the tunica albuginea of the corpora cavernosa. As it lies in the sheath it is connected to the walls by a very lax connective tissue, which evidently permits of a considerable amount of motion of the tendon within its canal.

Of the muscles met with on the lower surface of the penis, the ischio-cavernosus lies to the outer side, the bulbo-cavernosus to the inner, and the compressor of Cowper's gland between these two. In order to an accurate description of these muscles, it may be as well to refer briefly in the first place to the perineal fascia. On removing the skin and superficial fascia from the region of the perineum the deep or proper perineal fascia is seen to be of great strength, and forms a general covering to all the muscles of this region. It is attached on each side to the external margin of the corresponding crus penis, and is prolonged forward so as to form a distinct covering to the corpora cavernosa. From the deeper aspect of this portion of the fascia on each side of the middle line two processes of great strength dip down to be attached to the floor of the perineum. Of these, one intervenes between the ischio-cavernosus and compressor of Cowper's gland on the outer, and the bulbo-cavernosus on the inner side; whilst the other separates the ischio-cavernosus and compressor from one another. From this it will be seen that each of the perineal muscles is enclosed within a distinct fibrous capsule formed by the perineal fascia, and from certain of the aponeurotic septa just mentioned different muscles take their rise.

The *ischio-cavernosus* muscle is described by Cuvier as consisting of four distinct portions, but these I failed to recognise. It is a muscle of no great size, and possesses two distinct origins. The posterior of these having been removed from its attachment could not be seen, but in all probability it corresponded to the usual origin of this muscle from the ischial tuber. The anterior portion of the muscle, which is however quite continuous with the posterior, takes origin from the outer side of the dilated extremity of the corresponding crus penis. The fibres all pass obliquely forward and inward to be inserted into the inner aspect of the crus, and thus furnishes a muscular investment to the dilated portion of the corpus cavernosum. This muscle is separated from the others in this region by the septal processes already described.

Compressor of Cowper's gland. This muscle, which is mentioned but not described by Cuvier, is also referred to by Duvernoi under the name of the transverse muscle of the perineum. It would seem, moreover, that this is the muscle figured by Camper in his drawing under the name of the short accelerator urinæ. The muscle has a fascial origin and insertion. It arises from the outer side of the aponeurotic septum, which intervenes between it and the bulbo-cavernosus, as also from the inner side of that which separates it from the ischio-cavernosus. The fibres form an elliptical belly which embraces and conceals the perineal aspect of Cowper's gland. At the anterior extremity of this gland the fibres terminate on an aponeurotic septum, which is formed by the union of the two pieces of fascia which separate the muscle from its neighbours, and through the medium of this are inserted into the root of the corpus cavernosum. This muscle is to be regarded as connected physiologically with Cowper's gland, the secretion of which it is adapted to expel.

The *bulbo-cavernosus* muscle conceals the bulbous portion of the spongy body. It arises principally, along with the muscle of the opposite side, from a median tendinous raphè which rests upon the bulb. It has however an additional origin by means of an elongated fleshy slip from the aponeurotic structures which form the floor of the perineum, which slip arises, along with that of the opposite side, as far back as the origins of the compressors of Cowper's glands, between which muscles it lies. From these origins the fibres pass obliquely forward and outward, so as to embrace the bulb, and are inserted into that portion of the fibrous envelope of the penis which intervenes between the corpus cavernosum and spongiosum.

Transverse muscle of the perineum. Muscles distinct from those already described bearing this name, are figured by Camper, but such are not present in my dissection, nor are they mentioned by any other author.

Penis. This organ, which in Duvernoi's specimen measured 6 feet in length and weighed 80 pounds, in the present case measures 2½ feet from the attachment of the crus to the point. Each corpus cavernosum commences by a slightly dilated extremity where it is attached to the ischium, and coalesces at once with that of the opposite side, so as together to form two-thirds of the body of the penis, the remaining third being formed by the corpus spongiosum, each cavernous body diminishes gradually in transverse section from the root to the point of the penis, so that at a distance of 4 inches behind the glans each is diminished to one-third or one-fourth of its original diameter. The dilated extremity of each is covered by the ischio-cavernosus muscle. The corpora cavernosa are surrounded by a very strong fibrous envelope measuring one quarter of an inch in thickness at the root, but diminishing to one-half of this toward the point of the organ. From the middle of the dorsal portion of this investment a strong fibrous pectiniform septum dips down to separate the two cavernous bodies. This septum is very incomplete, and permits of the continuity of the cavernous tissue across the middle line. This tissue is disposed in the usual manner, being denser toward the circumference than at the centre of each cavernous body. The large septa described by Camper as subdividing each corpus cavernosum are readily seen in different sections of the penis, but they are quite irregular, and are nothing but trabeculæ of larger size than those forming the mass of the cavernous tissue.

The corpus spongiosum commences by an elongated bulbous extremity at the root, and tapers gradually to the point of the penis, so that in form, as remarked by Duvernoi, it may not inaptly be compared to a large carrot. At the anterior extremity of the dorsal aspect of the penis is an elongated body closely resembling the backward prolongation of the glans in the horse. It measures 3 inches in length, and 2½ in breadth, and is, I think, to be regarded as the glans. At the same time, it is to be observed that this body does not reach the point of the penis as in the horse, but is separated from it by a distance of 2 inches. Four inches behind the glans the spongy body does not measure in transverse section more than one-sixth of that of the bulbous portion. As regards its structure, the corpus spongiosum is similar to that of the corpus cavernosum, except in this respect, that the investing tunic of the former is much thinner than that of the latter, and, in fact, is little more than membranous. Through the upper part of the spongy tissue passes the canal of the urethra, and an imperfect median septum rising up from the lower part of the fibrous tunic is attached to the floor of that canal. This septum is distinct enough posteriorly, but disappears entirely toward the point of the penis. The bulbous portion is invested by the bulbo-cavernosi muscles, and into this portion of the urethra open the ducts of Cowper.

Vessels and nerves of the penis. Duvernoi describes an elaborate series of nervous and venous plexuses in connection with the penis, but these I failed to identify. The dorsal arteries lie one on either side of the middle line under cover of the corresponding levator penis. Each runs forward as far as the extremity of the organ, accompanied by the vein and nerve, the former lying to its inner, the latter to its outer side. In this course it gives off many branches for the supply of the organ, one of which, larger than the others, given off about the middle in length of the penis, runs obliquely downward and forward, to supply the lateral and inferior aspects of the organ.

The dorsal veins accompany the arteries lying to their inner side. Close to the root of the penis the veins of opposite sides communicate by a number of branches, so as to form a plexus on the dorsum of the organ, and this plexus communicates freely with the interior of the cavernous bodies. It will be observed, therefore, that there is not a single vein as stated by Owen, but that these correspond in number with that of the arteries.

The dorsal nerves accompany the vessels, and run as far as the extremity of the penis. In this course they give off many branches for the supply of the skin and other parts of the organ. Of the third, or median dorsal nerve described by Duvernoi as forming a remarkable plexus in this region, nothing could be seen. Neither was there any fat present.

Prepuce.—The skin is reflected from the penis just behind the glans, to form a well-marked prepuce.

The orifice of the urethra is, as stated by Camper, Y-shaped, the two limbs being directed upward, the stem downward.

DESCRIPTION OF PLATE IV.

Fig. 1. The injected ureter and calyces of the right kidney.

Fig. 2. The inferior surface of *a* the membranous part of the urethra. *b.* neck of the bladder. *cc.* vesiculæ seminales. *dd.* vasa deferentia. *ee.* prostate glands. The right vesicula and prostate have been opened.

Fig. 3. The canal of the membranous part of the urethra has been opened to display *a.* the vesicula prostatica; *b.* the bristles introduced into the ejaculatory ducts; *c.* those introduced into the prostatic ducts; *dd.* the openings of the ureters.

Fig. 4. Perineal muscles and fascia. *aa.* ischio-cavernosi. *bb.* bulbo-cavernosi. *cc.* compressors of Cowper's glands. *dd.* internal fibres of sphincter ani.

SOME OBSERVATIONS ON THE DENTITION OF THE NARWHAL (MONODON MONOCEROS[1]).

By Professor Turner.

It is the current belief of naturalists that, in the Narwhal, two teeth only are produced, both of which are situated in the upper jaw. In the female, as a rule, these teeth remain in a rudimentary state concealed within their sockets. In the male, on the other hand, the rule is for the right tooth only to remain rudimentary and concealed within its alveolus, but the left protrudes, grows in the adult to the length of several feet, and forms the well-known tusk or horn of this animal. Occasionally, however, the right tooth grows equally with the left, and like it projects for several feet beyond the mouth. In an interesting paper recently published Mr J. W. Clark of Cambridge[2] states that at least eleven bidental skulls may now be found in the various museums in Europe[3].

With regard to the position of these teeth in the upper jaw a difference of opinion has been expressed by anatomists. The illustrious Cuvier stated[4] that the teeth were implanted in the intermaxillary bones, or in an alveolus common to the maxilla and intermaxilla; and this view has been adopted by various subsequent writers, by some of whom the tusk has been regarded as a peculiarly modified incisor tooth. But in a paper read, some forty years ago, to the Royal Society of Edinburgh[5], Robert Knox pointed out that the tusks were carried in the maxillary bones; and this view of their position has recently been supported by Van Beneden and Gervais[6], J. W. Clark, and W. H. Flower[7].

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[1] Read before the Royal Society of Edinburgh, May 20th, 1872.

[2] *Proc. Zool. Soc.* Jan. 17, 1871.

[3] In the Anatomical Museum of the University of Edinburgh is the skull of a male Narwhal, from the left supr. maxilla of which a tusk 33 inches long projects. The right maxilla has been in part removed, and a canal has been exposed, which extends as far back as the base of the beak, and is nearly 1 inch in diameter. From its length and the size of its bore it is not improbable that in this skull the right tusk had been developed and had protruded from the jaw, but the tusk and loose piece of the jaw have been lost.

[4] *Ossemens fossiles*, v. Part I. 321, 322.

[5] *Transactions*, XI. p. 410. 1830.

[6] *Ostéographie des Cétacés*, p. 13.

[7] *British Medical Journal*, May 20, 1871.

Being desirous of satisfying myself on this point I have examined ten crania of this animal, all of which, with one exception, are in the Edinburgh Museums, and from what I have seen in them I entirely agree with the statement of the last-named anatomists. Five of these crania were males, three adult, and two from younger animals; two were females and three were well grown fœtuses, and in all the specimens the maxillo-premaxillary suture was placed to the inner side of the alveolus for the tusk. In the adult male skulls this suture was situated in the inner wall of the alveolus, and it is probably from this circumstance that Cuvier considered that the socket was hollowed out of both the premaxillary and maxillary bones. But in the female and fœtal crania the maxillary nature of the tooth was shown in so decided a manner that there could be no doubt as to its true position. In the female crania the teeth were situated close to the palatal surface of the bone, a little to the inner side of the outer edge of the maxilla, and in one specimen the rudimentary tooth lay concealed in its socket nearly two inches to the outer side of the maxillo-premaxillary suture. In the fœtal crania the maxillary and premaxillary bones were readily separable from each other, and the socket of each young tusk was entirely situated within the superior maxilla.

The apparent participation of the premaxilla, in the formation of the socket of the developed tusk in the adult male, is undoubtedly due to a partial absorption, during the growth of the tusk, of the thin inner wall of the alveolus next the maxillo-premaxillary suture, in consequence of which the premaxillary bone forms a small proportion of the inner wall of the socket.

Owing to the maxillary position of the tusk it can no longer, therefore, be regarded as a peculiarly modified incisor tooth, but as it lies immediately to the outer side of the maxillo-premaxillary suture it should be regarded as representing a canine tooth.

In the course of my observations on the fœtal crania, and on that of a young male, I observed an appearance which led me to think that, in addition to the well-known pair of teeth in the upper jaw, each superior maxillary bone had at one time contained another tooth. For situated close to the outer border of the palatal surface of this bone was a canal, which passed backwards, parallel and inferior to the tusk-socket. In the young male this canal was two inches long, and opened in front one and a half inch behind the mouth of the socket for the tusk. It had the appearance of an alveolus, and on illuminating its interior, by reflecting light from the surface of a mirror, I perceived a minute denticle at the bottom of the socket.

Being so fortunate as to possess, through the kindness of Mr. C. W. Peach, a young male Narwhal (seven and a quarter inches long) with all the soft parts uninjured, I thought that I might perhaps be able to determine in it whether the Narwhal had originally more than two teeth developed in connection with its upper jaw. The surface of its palate was smooth and covered by mucous membrane, continuous with the tegumentary covering of the upper lip, but there was no appearance of teeth on the surface. When the more superficial part of the gum was however carefully cut off, two well-defined dental papillæ, each contained in its own tooth-sac, were exposed, imbedded in and completely enclosed by the gum which covered the outer edge of each half of the upper jaw, so that I can now state definitely that the Narwhal, at this early stage of development, possesses four teeth in the upper jaw. The more anterior of the two papillæ was two-tenths of an inch behind the tip of the jaw, and the more posterior lay about one-tenth of an inch behind the anterior.

Each dental papilla was so small as to be barely visible to the naked eye, and required the microscope to be employed for its further examination. Each papilla was continuous at its base with the connective tissue of the mucous membrane of the gum, from which it projected into the cavity of the closed-in tooth-sac. It was somewhat clavate in form, and was separated from the inner surface of the tooth-sac by a slight interval. When examined with high powers of the microscope, the papilla was seen to consist of small, pale, nucleated corpuscles, imbedded in a delicate and apparently homogeneous matrix. Some of these corpuscles were rounded, others oval, whilst others again were distinctly caudate. Corpuscles, similar in form, were collected in considerable numbers at the base, and in the connective tissue immediately adjacent to the base of the papilla, whilst throughout the connective tissue of the gum numerous characteristic connective tissue-corpuscles were seen. There was no trace of calcification of the dental papilla. The free surface of the papilla was limited by a sharp, definite outline, as if a membrana limitans invested it, but no distinct separable membrane was demonstrated, so that the sharpness of definition was probably due to the tissue of the papilla being more condensed near the surface.

The wall of the tooth-sac was entirely surrounded by the connective tissue of the mucous membrane. Its relation to the dental papilla showed it to be homologous with the enamel organ in man and those animals where enamel enters into the structure of the teeth. All connection was severed between it and the epithelium of the mouth, of which it had been, in all probability, originally an involution. It measured about $\frac{1}{50}$th of an inch in thickness, and was not homogeneous, for its outer and inner portions were denser than a more delicate intermediate portion. It was composed of pale nucleated corpuscles, about equal in size to those which entered into the formation of the dental papilla. These corpuscles were ovoid in form, and I failed to recognise any elongation of the cells which formed the inner portion of the tooth-sac into columnar epithelium, by the calcification of which the rods or prisms of the enamel are produced in man and in those animals in which enamel forms a part of the structure of the tooth. No membrana limitans was seen on either the inner or outer surfaces of the wall of the tooth-sac.

It is customary to state that the tusk of the Narwhal is destitute of enamel, and consists of dentine with an external covering of cement. As the examination of this young fœtus revealed the existence of a structure homologous with an enamel organ, though at a stage too early to exhibit its characteristic epithelium, I thought it advisable to examine anew the microscopic character of the tusk to see if there might not be, especially at the tip, some trace of an enamel covering. I accordingly removed a thin slice from the tip of one of the unprotruded, and therefore unworn, tusks of a well-grown fœtus. The general substance of the tusk consisted of well-formed dentine, but at the tip a depression extended for some distance into this tissue. This depression was filled up with crusta petrosa, continuous with that which formed the external investment of the tusk. The crusta in the immediate neighbourhood of this depression contained not only lacunæ with canaliculi proceeding from them, but groups of fine canals, which resembled in size and appearance dentine tubes. Between the dentine and the crusta petrosa was a thin ill-defined layer into which the dentine tubes penetrated, and which obviously corresponded to the so-called granular layer of the dentine in a human tooth. No trace of enamel rods could be seen.

The inner surface of the wall of the tooth-sac was not perfectly smooth, but possessed one or more ridge-like projections, which fitted into corresponding depressions on the outer surface of the dental papilla. It is, without doubt, to this arrangement, that the depression in the dentine at the tip of the tusk of the well-grown fœtus owes its origin.

There is no reason to think that the more anterior of the two teeth seen on each side of the upper jaw of this fœtus had to the more posterior the relation of a milk-tooth to a permanent tooth. For they were both almost precisely equal in size and in comparative development, which would not have been the case if the latter had had to act as the successor to the former. In all probability the more anterior would have developed into the maxillary tusk, and the posterior either have disappeared altogether, or formed one of those irregular non-protruding teeth, such as Berthold described some years ago in the skull of a young Narwhal which he examined[1].

No rudimentary teeth were found in the lower jaw, although it was carefully examined.

The ossification of the fibrous basis of the maxillary bones was so imperfect that it was not possible to distinguish the maxillary from the premaxillary segment. But in the lower jaw, the ossification of the fibrous membrane, which invested Meckel's cartilage, had advanced to a considerable extent.

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[1] Müller's *Archiv*, 1850, p. 386.

TISSUE METABOLISM, OR THE ARTIFICIAL INDUCTION OF STRUCTURAL CHANGES IN LIVING ORGANISMS. By W. AINSLIE HOLLIS, M.D. *Cantab.* Part II. Actiniæ continued. (Pl. VI.)

I HAVE elsewhere[1] given an account of some experiments instituted by me with a view to ascertain the structural changes which can be induced artificially in the tissues of these lowly organised beings. I intend here giving a short résumé of some further researches on the same subject.

Experiment 6. *The application of acetic acid.* August 3, **1.45** P.M. A greenish brown anemone (A. Mesembrianthemum) was touched with strong acetic acid, whilst withdrawn from the tank, it was next washed with sea-water and replaced in the vessel. A minute after the operation the injured part appeared swollen and paler than the surrounding tissues, it was also incapable of reaction to slight stimulus (such as that made by scratching it with the point of a steel style); the animal immediately contracted itself after the operation. 3 P. M. Integument of wound of a brownish red hue, and covered with a pultaceous muciform mass and swollen. This material was examined microscopically, and was found to contain a large number of elongated corpuscles with nuclei (Fig. 3). It was very tenacious. The animal was collapsed and had partially relaxed its hold of the vessel it was placed in. August 4th, **11** A.M. The injured portion (*a*) elevated and surrounded by contracting healthy tissues. The anemone partially expanded. On touching (*a*) with a style it was readily removed, and it left a whitish constricted scar composed of the subintegumentary tissues. (*a*) examined microscopically. Reddish brown colour and diffluent. It contained many spheroidal corpuscles, granules, and oat-shaped bodies, with a few ciliated animalcules. Pulsating movements were observable in some of the corpuscles. A small quantity of the exudation from the surface of

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[1] *Journ. of Anat.* VI. p. 381.

the newly-formed scar was carefully removed by a capillary glass tube and examined microscopically (Fig. 8). Several hyaline spheroidal corpuscles of various sizes were seen. No movements apparent in any of them. Several of the smaller corpuscles were double. August 5th, 2 P.M. Wound considerably puckered. Surface whitish. The healthy tissues elevated around it. Sept. 4th. Anemone healthy. The injured part indistinguishable from the other tissues except by its colour, which is an uniform pale green and unstriated (as is the rest of the body) with brown.

The two following experiments were made in consequence of a suggestion of Mr Savory, whom I have to thank for several valuable hints in the prosecution of these researches.

Experiment 7. The *injection of fœtid sea-water into an actinia.* July 26th, 1872, 3 P.M. Made an incision in the base of an anemone (A. Mesembrianthemum) and injected fœtid sea-water in which some decomposed crab-flesh had been steeped for several days. The injected water was very offensive to the smell, but under the microscope (× 250) gave no signs of organic life; the water was, however, full of dead amorphous particles of matter. Immediately after the operation the animal contracted itself. At 3.10 P.M. the point at which the incision took place was depressed, and the surrounding tissues were thrown into longitudinal and transverse folds. July 28, 10.30 A.M. Actinia contracted since last note. Scar still depressed. August 3rd, morning. Anemone healthy; no apparent result.

Thinking that the negative results of this experiment might have been due to the difference between the natures of the decomposing tissues and the tissues of the anemone, I made the following experiment.

Experiment 8. *The injection of a portion of the slough* (*a*) *of Experiment* 6 *into a healthy anemone.* August 4th, 11.45 A.M. Injected a portion of the slough (*a*) of Experiment 6 by means of a common hypodermic syringe into a brownish-green anemone. The anemone immediately contracted. Wound depressed. August 5th, noon. Anemone partly expanded, tentacles lax and flaccid. 5.15 P.M. The animal was closed, wound still depressed. August 14th. The anemone has been contracted for the past few days. Wounds inconspicuous, no apparent result[1].

The following experiment shews that the evolution of plasmic bodies may take place in a part of these creatures after its removal from their body.

Experiment 9. *The abscision of a tentacle and the subsequent application of acetic acid to the abscised portion.* August 8, noon. Tentacle abscised[2]. 12.15 P.M. A drop of acetic acid placed on it for an instant, and the tentacle was then washed with sea-water. It was next placed on a glass slide for microscopical examination, and so covered with a thin glass that no pressure was exerted upon it[3]. 12.30 P.M. The surface was contracted into deep rugæ and surrounded by a web of delicate thread-like bodies, hyaline, spheroidal and spindle-shaped corpuscles and a few granules. The tentacle was removed from the glass slide and placed in a vessel of sea-water containing other actiniæ. August 9th, 1 P.M. Tentacle dead and textures soft and undergoing disintegration. Numerous ciliated animalcules[4] in various stages of growth were amongst the decaying textures.

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[1] Since performing these two last experiments I have injected some decaying anemone-tissue swarming with ciliated animalcules into a healthy actinia, but with no definite result.

[2] It may be as well to state that a tentacle, when placed in sea-water after abscission, will continue to shew signs of vitality for some hours.

[3] I found this precaution necessary, as I was previously led astray somewhat in several similar experiments by the rapid evolution of spheroidal corpuscles, after the application of the thin glass. This evolution was induced to some considerable extent by the pressure thus exerted upon the tentacle.

[4] I am pleased to find that Prof. Haeckel of Jena, in his recent researches, has arrived at the same conclusion with regard to the constitution and the nature of the movements of cilia in such animals as I have done (*Journ. of Anat.* VI. p. 381). He now considers cilia (*Biolog. Studien*, noticed in *Arch. de Zoolog. Expérim. et Générale*, I. p. XLI. 1872) as 'prolongations of the protoplasma of the mass called, according to the cellular theory, by the name of cellule,' and that their movements are amœboid. Recent researches into the evolution of the lowest forms of animal life would lead me to conjecture that possibly the locomotive corpuscles, ciliated animalcules and vermiform animals (*Journ. of Anat.* VI. pp. 384—5), described by me as the parasites of actiniæ, are different forms of the same creature, and are allied to the Euglenia, figured in Dr Bastian's work (*Beginnings of Life*, II. p. 526). Dr Cobbold curiously enough gives the figure of a nematode (*Brit. Med. Journ.* 1872, II. 89), very similar in shape to the vermiform animals found in actiniæ. This nematode was found by him in the urine of a patient afflicted with the ciliated Bilharsia Hæmatobia. I have, however, been unable to trace any connection between the ciliated animalcules and the vermiform animals in my researches. That the former originate in locomotive corpuscles I think exceedingly probable. I cannot understand why Prof. Rolleston considers that 'the *spermatozoa* of parasitic nematoids are spherical or ovoidal cells' (*Forms of Animal Life*, p. CXXXV. 1870), 'and move

I give the details of the following experiment with blistering fluid (although similar experiments have been noticed previously), as it illustrates better than the others the way by which the healing processes after irritation are carried on in these animals.

Experiment 10. *The application of blistering fluid to the tentacles of an Actinia Mesembrianthemum.* Aug. 12th, 1872, 3.40 P.M. Touched a few tentacles of a red anemone (A. Mesem.) with blistering fluid. 3.50 P.M. The touched tentacles lax, swollen and semitransparent. On removing from them a little muciform débris on a style for microscopical examination, there were found in it numerous spindle-shaped corpuscles, and a few spheroidal ones with granules (Fig. 4). 5 P.M. The blistering fluid had run over the pedicle as well as the tentacles. The injured parts were paler and brighter coloured than the rest of the body, and were covered with a diffluent muciform reddish matter. On microscopical examination this diffluent material was found to contain strings and agglomerations of hyalined spheroidal, and spindle-shaped corpuscles (Fig. 5), the former were far more numerous than they were in the muciform fluid at the first examination ten minutes after the injury. August 13th, 2 P.M. The anemone partly expanded. The tentacular ring on the side of the injury contracted. The extremities of some of the injured tentacles had sloughed off. The subintegumentary tissue (after removal of a pultaceous débris) was laid bare in many places. On microscopical examination the débris was found to contain a large quantity of hyaline corpuscles, many of which were spheroidal in shape and had depressed centres (Fig. 6). August 14th, 11 A.M. Anemone contracted and the injured parts covered with a reddish muciform débris, the consistence of which was greater than that of yesterday. On its removal the creature was found in the parts corresponding to the scoring of the integument to be covered with small nodules of tubules. The débris consisted mostly of spheroidal-shaped corpuscles arranged in rows and laterally compressed (Fig. 7). Aug. 16th, 8.25 A.M. Anemone con-

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only by the protrusion of pseudopodial protoplasmic processes.' To call such creatures spermatozoa appears to be asserting more than the facts of the case justify.

tracted on the side of the injury, elsewhere partially expanded. Débris scanty.

No further examination of the débris was made in this case. The next experiment illustrates the operation of nitric acid on the tissues of these animals.

Experiment 11. *The application of nitric acid to an Actinia Mesembrianthemum.* July 16th, 4 P.M. Touched a greenish-brown anemone with strong nitric acid. Afterwards carefully washed it in sea-water, until the washings had no acid reaction. Immediately after the operation the animal forsook its hold of the vessel in which it was placed, and became strongly contracted. The part touched assumed a reddish-brown hue, and the surrounding tissues were thrown into fine corrugations. July 17th, 10 A.M. The animal was found attached to the vessel with the wounded part dependent. The tentacles on the upper side were expanded. The creature ate food when it was offered to it. The wound was covered with a pultaceous reddish-brown mass; the rest of the integument was of a greenish-brown colour. On microscopical examination the débris was found to consist of a few granular corpuscles in a delicate nearly homogeneous mass. July 18th, 4 P.M. The animal still expanded. The reddish-brown slough covering the injured parts easily separated from the animal. It was found to consist of muscular fibres, granules and locomotive corpuscles. The scar white and depressed. *Administration of Chloroform.* July 24th, 1.30 P.M. Animal contracted, the cicatrix puckered and depressed. Stomachal orifice drawn towards the scar. Chloroform vapour was applied to the creature at 2.30 P.M. The immediate effect of the vapour was the production of an œdema of the integument except at the scar, and a total loss of the power of reaction to stimuli. The effects of the drug lasted for about half-an-hour. July 28th. Scar still puckered and depressed. Anemone healthy. September 5th. The cicatrix only to be distinguished from the surrounding tissues by the colour, which is greenish, and unstriated, as is the rest of the body, with brown.

Recapitulation and Summary of the experiments upon Actiniæ. 1. The application of an irritant to these animals produces (as before noticed) swelling of the tissues. This swelling consists essentially in a diminution of the tonic contractile force residing in the healthy tissues, and is accompanied by a loss (more or less considerable) of the power of reaction of injured tissues to stimuli.

2. The swelling of the tissues is usually accompanied by an immediate production of a muciform fluid, but in such cases different irritants produce different results. This fluid is at first nearly colourless, and contains numerous spindle-shaped, with few spheroidal, corpuscles and granules. The above phenomena (i.e. the swelling of the tissues and the production of the muciform fluid) may be excited by the application of an irritant to a still-living part after its removal from the body.

3. If the cause of the irritation be prolonged and violent, disintegration of the tissues takes place—and one of the following events occurs: *a.* A slough is formed of the decayed tissues and is cast off, leaving a contracting cicatrix of healthy tissues bathed in a little muciform fluid similar to that described above (§ 2). *β.* The disintegrating tissues become gradually eroded, and the clear muciform fluid surrounding the injured part becomes more tenacious and opaque[1], and contains a large number of spheroidal and other corpuscular elements elsewhere described (*Journ. of Anat.* VI. p. 393).

4. The injection of a solution of decomposing tissues into the healthy animal does not (as far as my experience goes) induce any disintegrating effect upon the tissues with which such a solution is brought into contact.

ANNULATA.

The next series of experiments I shall describe are some illustrating the tissue-changes which take place after the application of an irritant to the integument of the common earthworm (Lumbricus Terrestris). It will not be necessary for me to recapitulate the minute anatomy of this creature, as that has already been most ably done by Mr E. Ray Lankester[2];

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[1] In my previous paper (VI. p. 393) I described this fluid as greenish-yellow. I find, however, from some experiments since undertaken with red-coloured actiniæ that the fluid simulates more or less closely the colour of the healthy tissues.

[2] *Quart. Journ. of Microsc. Sc.* New Series, IV. 259, and V. 7 and 99.

and, as far as the nervous system is concerned, by Mr (now Dr) Lockhart Clarke[1]. There are, however, one or two particulars in the anatomy of the earthworm in which my own investigations have led me to differ somewhat from the generally accepted statements concerning it, these I shall here shortly notice.

The vascular and perivisceral fluids. The tissues of Lumbricus terrestris are very generally intersected by numerous vessels containing a red fluid, coagulable on the addition of nitric acid. This vascular fluid is usually described as non-corpusculated, and as thus not truly representing the blood of vertebrates. I have, however, after numerous carefully conducted experiments, arrived at the conclusion that this apparently homogeneous fluid in reality contains hyaline corpuscles and granules in variable quantity. Similar corpuscles, only in greater numbers, and occasionally with amœboid-like processes, are seen in the clear perivisceral fluid which bathes the splanchnic cavity between the coats of the alimentary canal and the inner wall of the integument. The corpuscular elements upon the addition of acetic acid separate into a delicate external envelope and internal granular contents. The granules are either free or in groups, and, when seen in conglomerate masses, are of a greenish tint[2]. They are unaffected by benzine (Fig. 1). The perivisceral fluid varies greatly in quantity, at times barely sufficing to bathe the external walls of the gastro-intestinal canal.

Their parasites. In the muscular layers of the tegumentary walls numerous vermiform animals are found (the *Anguillula Lumbrici* of Dujardin, the small nematoid of Lankester). They are in external respects and in size similar to the vermiform parasites of actiniæ. Like them the anterior or oral extremity is pointed, and the alimentary canal passes without convolutions to within a short distance of their somewhat obtuse caudal end. On either side of the canal can be seen small granular particles, similar to those found floating freely in the blood of their host. These granules, when seen in the mass, have a

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[1] *Proc. Royal Soc.* 1857, pp. 344—352.

[2] These bodies are similar in appearance to those observed by me in actiniæ (*Opus jam cit.* p. 387).

greenish tint. These parasites do not die immediately they are immersed in sea-water, although their salt-water congeners rapidly expire when placed in fresh water. When coiled up amongst the muscular fibres of their host, they present an appearance not dissimilar to encysted *Trichinæ*.

I shall now proceed to detail some experiments I have undertaken, with a view to observe the tissue-changes that can be induced in these animals by the application of irritants to their integument.

Experiment 1. *The application of blistering fluid to an earthworm.* July 30, 3 P.M. Applied Liquor Epispasticus to sixteen segments of the tail extremity of a young healthy Lumbricus, leaving seventeen caudal segments posterior to those injured untouched. 3.10 P.M. The injured part pinkish white and swollen. No vermicular motion in it, although the healthy segments behind it moved freely. 3.20 P.M. The tail behind the seat of injury of a pink hue from congestion of the capillaries, no contraction of dorsal vessel in or behind the wound.

July 31, 11 A.M. The last thirty-five segments had separated from the rest of the worm. The terminal segment of worm somewhat obtuse, but the cicatrix at this point scarcely distinguishable from the healthy caudal end: worm active and lively. The detached end (*a*) was found to be almost entirely destitute of vitality, a slight retraction of the anal orifice was, however, induced upon irritating this extremity. The part (*a*) where the blistering fluid was applied was of a deep red colour above, and the epidermis was removed—the colour gradually faded off below where the integument was persistent. The remainder of '*a*' was of a pale straw colour. The dorsal vessel was much congested along the denuded part. On examining microscopically a portion of the abraded skin several nematode worms were seen. The corium and muscular layers next examined. Capillaries intensely congested (Fig. 2). Extravasations of blood in parts. Corpuscles with shrunken centres, resembling the red corpuscles of mammals, were also seen. It is possible that this form is assumed by these bodies after immersion in water, the medium in which they were examined. The dorsal vessel of '*a*' was next carefully pricked, and a drop of the dark-red-blood exuding introduced into a clean capillary glass tube, and afterwards examined microscopically. It was found to contain numerous corpuscles of various sizes, the larger with a distinct red hue. The blood was coagulable with nitric acid; and the corpuscular elements in it were without motion. August 3rd, worm healthy.

Experiment 2. *The application of acetic acid to an earthworm.* August 3rd, 1872, 1.30 P.M. Touched seventeen segments of the same worm as that previously experimented on with acetic acid. The injured portion extended to within ten segments of the freshly cicatrised caudal extremity. Immediately after the operation the integument became white and swollen, and the injured part apparently lost the power of motion, although the ten healthy segments behind it still retained that power. Upon examining the injured part ten minutes later with a magnifying glass, several subcuticular segmental blood-vessels and their capillaries were seen to be congested. The part had now assumed a distinct pink hue; there was pulsation of the abdominal vessel behind the injury, although no distinct movement was detected at the seat of the operation. 4 P.M. The last twenty-nine segments (α) partially separated from the rest of the body by a fissure on the left side extending into the abdominal cavity. The fissure, apparently caused by the violent tonic (hour-glass) contractions of a segmental set of muscles. The injured portion somewhat redder and more swollen than when last observed. The last ten segments still retained the power of vermicular contraction. August 4th, 12.15 P.M. The part 'α' separated at the fissure from the rest of the worm. It still retained some power of independent motion in the ten terminal segments. A capillary tube was applied to the caudal extremity of the living worm, and a small quantity of fluid taken up thence and examined microscopically (Fig. 9). It contained hyaline corpuscles and oblong bodies of various sizes. Whilst I was examining the worm, and holding its caudal segments between my fingers, about ten segments (β) at the part were suddenly thrown off. Some slight movements in the dorsal vessel of 'β' after its separation.

The application of irritants to the segments separated from the living worm. 12.30 P.M. Blistering fluid was applied to the still moving extremity of 'α'; to 'β' a small quantity of acetic acid. Five minutes after the application 'a' was white at the part and swollen. A blebs appeared to be produced. It still retained some independent motion. 'β' swollen and of a pinkish-white colour, it appeared to have lost all contractile power. The bulla of 'a' pricked and a little fluid withdrawn. On microscopical examination there were seen several spheroidal and oblong corpuscles (as in Fig. 9, only somewhat smaller as a rule), granules, and nematode parasites. August 5. Both extremities (a and β) dead. Worm healthy.

Experiment 3. *The injection of decayed animal matter into an earthworm.* August 13, 1872. 3 P.M. Injected into the fiftieth segment from the head of a young lumbricus a drop of fresh water, containing corpuscles from the slough of an actinia (obtained in Experiment 10 on those animals). Immediately after the experiment the segments at the seat of injury became slightly congested. August 14th, 11.30 A.M. Worm lively. At the point of puncture a small elevation of the skin with a thick whitish fluid beneath it. This fluid on microscopical examination was seen to consist of plasmic elements of various shapes, mostly spheroidal, some granules, pyriform and staff-shaped corpuscles (bacillæ) floating in a little hyaline fluid (Fig. 11). August 16, 12.10 P.M. The puncture still covered with a flap of skin and surrounded by a dark line (? congested capillaries). Unfortunately absence from town prevented me from completing my observations on this animal. It is now (Sept. 28th) alive and healthy and the wound inconspicuous.

As several experiments in which I had attempted to induce a higher stage of tissue-irritation than the mere elevation of the epidermis, and the production of a partially filled bulla, resulted in the separation of the worm at the point of injury, and the rapid death of the discarded segments, I undertook the following experiment, in which by limiting the size of the injury to a small local wound, and by repeated applications of an irritant to this spot, I hoped to produce some of the further changes in tissue formation, which only take place after the lapse of some days from the first injury.

Experiment 4. *The repeated application of irritants to certain segments of an earthworm.* Sept. 25th, 4 P.M. Applied blistering fluid to a large specimen of Lumbricus Terrestris, forty segments from the end. This, as usual, induced a rapid wriggling movement of the worm. Sept. 26th, 2.45 P.M. Injured part an oval in shape, on the side of the worm, and extending over three segments. Epidermis at this point elevated and wrinkled, whitish. Segmental divisions, fully separated at the side of the injury, were there destitute of contractile power and sensation apparently; they were on the opposite side closely contracted, thus bending the body into an angle, of which the wound formed the apex. No capillary congestion was seen, but this may have been partly due to the thickness of the integument in this specimen, the dorsal vessel being scarcely visible through the skin. Placed a small quantity of acetic acid on the injured part, the epidermis immediately became elevated, semi-lucent. and tense. No wriggling of the worm took place on the application of the acetic acid. Worm active and lively. Sept. 27th, 2.10 P.M. Injured segments elevated, tense, and yellowish. Second application of acetic acid to the part. No movement of the worm at first after the operation; the acid, however, subsequently 'ran over' a fresh portion of the integument, when the wriggling immediately commenced. Sept. 28th, 10.30 A.M. Injured segments, now eight in number, the wound of an oval shape, prominent, whitish at the sides, and reddish-brown in the centre. Epidermis removed for about a line over most prominent part, where the integument constantly exuded moisture. A small incision was made at this point and a little milky fluid withdrawn by a clean capillary tube and examined microscopically. It consisted of a very large number of hyaline corpuscles, mostly spheroidal, some, however, oblong and pyriform in shape. There were also numerous granules, in conglomerate masses generally, and of a greenish tint; again, long stringy masses of plasma (fibrillæ). These fibrillæ appeared to contain spheroidal corpuscles in their substance occasionally (Fig. 12). The prominent part was again touched with acetic acid and the worm replaced in the case by itself. Sept. 29th, 10 A.M. Worm active and lively. The wound of a yellower tint than it was yesterday. Acetic acid again applied to the most prominent portion. Sept. 30th, morning. Wound yellow and depressed.

The lips of incision everted and elevated. A deep sulcus, anteriorly, separated healthy from diseased tissues. No actual fissure. Touched the wound with blistering fluid.

Oct. 1st, 3.15 P.M. The worm was divided at the segment anterior to the wound and healthy. Posterior (discarded) segments exhibited signs of vitality. On examining microscopically the fluid escaping from the surface of the wound, numerous pyriform and a few spheroidal corpuscles were observed. The edges of the wound retracted, colour brownish-yellow in the centre, greyish-white at the sides where the epidermis was elevated. On a clean section being made through the diseased tissues, they were found to be softer, less coherent, and moister than natural. The injury extended inwards as far as the intestinal walls. The diaphragmatic blood-vessels near the seat of injury greatly congested. The subsequent microscopic examination shewed the natural tissues loose, shreddy, fibrils broken, and a large quantity of amorphous plasma appeared to have been poured out at one part between the muscular constituents of the integument. There were also numerous granules and plastic fibrils, few corpuscular elements; the fibrils were in parts granular. At one point, however, I observed a considerable number of pyriform and spheroidal corpuscles. The absence of the corpuscular element to such a considerable extent in the metabolic processes observable in these creatures surprised me considerably. The evolution of plasma in amorphic or fibrillar masses appears to take the place of the spheroidal element in these animals, when the tissue-changes are far advanced. The pyriform corpuscles seen in the earlier stages of irritation seem to me to be only an imperfect evolution of the spheroidal form, due possibly to an increased rapidity in the production of such elements. Oct. 2nd. Worm healthy. Discarded terminal segments dead.

Summary. From the above experiments it is shewn that in the common earthworm, irritants, when applied to the integument, produce:—1. Swelling of the implicated tissues and loss of contractile power. 2. Elevation of the epidermis from the true cutis. 3. The moderate production of corpuscular (pyriform, spheroidal, and granular) elements beneath the raised epidermal layer. 4. The congestion of the capillaries in proximity to the injured parts. If the irritation be prolonged, besides the above named phenomena, we also find a softening and disintregation of the tissues implicated, together with the production of amorphous, fibrillar and other plasmic elements.

Conclusion. I conclude that most (if not all) the above phenomena denote a loss of the tonic vital contractility naturally inherent to the healthy tissues, and their consequent incapacity to react under stimulation.

Connotation of the metabolic phenomena observable in Actiniæ and Lumbrici.

The application of an irritant to the integument induces

In Actiniæ :—	In Lumbrici :—
1. Swelling and loss of contractility in the injured tissues.	1. Swelling and loss of contractility in the injured tissues.
2. The production of a muciform fluid containing spindle-shaped and spheroidal corpuscles with granular matter.	2. Elevation of the epidermis and the production of pyriform, spheroidal, and granular elements held in a little hyaline fluid.
3. Softening and disintegration of the tissues with either their subsequent removal from the body or the evolution of a large quantity of spheroidal and other elements.	3. Softening and disintegration of the tissues affected, with either their removal from the body, or their subsequent infiltration with amorphous, fibrillar, spheroidal, and other plasmic elements.
4. The phenomena described in the first two sections can be induced in the tissues of a part freshly removed from the body.	4. The phenomena described in the first two sections can be induced in the tissues of a part freshly removed from the body.

DESCRIPTION OF THE FIGURES.

Fig. 1. Corpuscles from the healthy blood of an earth-worm, *a, a,* amœboid-like corpuscles (× 250).

Fig. 2. Congested blood-vessels from around ventral nerve-cord after irritation of integument of an earth-worm (× 90).

Fig. 3. Tissue débris (75 minutes) after the application of acetic acid to an actinia mesembrianthemum (× 250).

Fig. 4. Tissue proliferation (10 minutes) after the application of blistering fluid to an anemone (× 250, p. 83).

Fig. 5. Tissue proliferation from the same specimen, as preceding figure, about an hour and a quarter later (× 250, p. 83).

Fig. 6. From the same specimen as the two preceding figures about 21 hours after the injury (× 250, p. 83).

Fig. 7. From the same specimen as the three preceding figures, 43 hours after injury (× 250, p. 83).

Fig. 8. Corpuscles from a healing surface immediately after the removal of a slough from an anemone (× 250).

Fig. 9. The same from an earth-worm (× 250).

Fig. 10. The same as preceding figure after the addition of acetic acid, shewing the contraction of the corpuscular contents (× 250).

Fig. 11. Corpuscles from beneath epidermis of L. Terrestris about 20 hours after injection of fœtid matter into its body (× 250, p. 89).

Fig. 12. Fibrillæ and corpuscles from tissue-proliferation after prolonged irritation. L. Terrestris (× 250, p. 90).

N.B. Examined in water.

OBSERVATIONS ON THE DISTRIBUTION OF SOME OF THE NERVES OF THE HEAD AND NECK.

By D. J. Cunningham, *Student of Medicine in the University of Edinburgh.*

At the suggestion of Professor Turner, and in conjunction with my fellow-student Mr G. Kirkwood, I have recently made a careful dissection of the Nerves of the Head and Neck, in order, if possible, to throw some additional light upon the nervous system in this region. And, though I cannot claim to have discovered anything altogether unknown, I think that I have been able to trace the connections and distribution of some nerves, which had not so been traced before, and this may perhaps lead to the rectification of some old theories and the confirmation of others. The points which I have chiefly noticed as being less or more new are as follows:—

Superior Cervical Ganglion of the Sympathetic.—Two branches of small size proceeded from this ganglion, passed through the prevertebral muscles, and finally terminated in the ligaments and vertebræ of the upper cervical region. These branches are not mentioned in any of the books I have consulted. The connection which existed between the sub-occipital nerve and the ganglion was very intimate. I found a whole series of branches—4 or 5 in number—passing from one to the other. Before the sub-occipital nerve disappeared from view over the transverse process of the atlas, it gave off a few twigs which passed to the articulation between the occipital bone and the atlas, and acted doubtless as the nerves of supply to this important joint. These branches have (according to Quain) been described by Valentin. I may mention that I could find no branch of communication passing between the superior cervical ganglion and the spinal accessory nerve, and no such branch has been described so far as I am aware; but it is strange that this ganglion, which is so liberal in giving off branches to the other two divisions of the eighth cranial nerve, should fail entirely in bestowing a similar favour upon the spinal accessory.

With regard to the *Middle Cervical Ganglion* I was able to make out the following points:—As the phrenic nerve lay between the fourth and fifth cervical nerves, a slender branch of communication passed between it and the middle cervical ganglion. This communicating nerve gave off a slender but strong branch to the coat of the transversalis colli artery, to which it doubtless acted as the vaso-motor nerve. A well-marked sympathetic plexus surrounded the inferior thyroid artery, and communicated with the fourth and fifth cervical nerves. From the fifth cervical nerve an accessory phrenic arose, and passed down on the surface of the scalenus anticus external to the phrenic itself and to the outer side of the internal mammary artery, to enter the thorax and join the phrenic nerve in the upper part of that cavity. This is an abnormality which, according to Krause, rarely occurs; but two cases of an almost similar nature have been described by Prof. Turner in this *Journal*, VI. p. 102. In connection with the *Inferior Cervical Ganglion,* I found a slender branch of communication passing between it and the phrenic nerve. Both this branch and that from the middle cervical ganglion to the phrenic nerve are mentioned by Krause and Telgmann[1]. Mr Kirkwood was able to make out, on the opposite side of the body, a connection between the inferior ganglion and the pharyngeal plexus. This branch passed up behind the sheath of the common carotid artery and, resting upon the prevertebral muscles, joined the lower part of the plexus.

Long Buccal Nerve.—An additional proof that its function is sensory and not motor as is often represented.

On two occasions Prof. Turner has seen this nerve coming off from the superior maxillary division of the fifth cranial nerve[2], a trunk which has never been doubted to be sensory—and it is known that when the muscles of expression are paralysed the buccinator muscle (of which the long buccal is often represented as the motor nerve) is paralysed with them, and that when the muscles of mastication are paralysed the buccinator muscle is unaffected. These two facts are almost sufficient of themselves to prove the sensory function of this nerve, but, as additional evidence might be obtained by dissection, I followed out the branches of distribution of this nerve very

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[1] *Die Varietäten der Nerven,* Leipzig, 1868.

[2] This *Journal,* November, 1866, and *Proc. Roy. Soc.* London, 1868.

carefully with the following result. Of the numerous branches, which the long buccal gives off, as it emerges from under cover of the ramus of the jaw, I succeeded in finding only two which did not in any way communicate with the facial nerve. These I traced through the muscular fibres of the buccinator muscle by dissecting it with needles under water, and found that they broke up into a great number of very minute branches, which entered the sub-mucous coat of the mucous membrane of the cheek. In my dissection I failed to find a pure facial branch entering the buccinator muscle, and this muscle was too much torn up to allow of my tracing one of the mixed branches.

Posterior Auricular Nerve.—There appears to be some difference of opinion in regard to the distribution of this nerve. Quain[1] and Ellis[2] describe it as supplying the posterior belly of the occipito-frontalis muscle and the retrahent muscle of the auricle, whilst by Flourens the posterior belly of the occipito-frontalis is represented as being supplied by the small occipital nerve. To settle this point Mr Kirkwood made a careful dissection of the nerve. After leaving the facial nerve close to the stylo-mastoid foramen it divided into two branches in front of the mastoid process. One of these proceeded upwards for a short distance, then passed beneath the posterior belly of the occipito-frontalis and broke up into branches, which entered the deep surface of this muscle. The second division of the nerve ran backwards under cover of the retrahens aurem, and, giving a branch to the deep surface of this muscle, curved round the pinna, and gave branches to the deep surface of the attolens and attrahens aurem. It is thus seen that the posterior auricular nerve is to be looked upon as the motor nerve to all three muscles of the auricle and also to the posterior belly of the occipito-frontalis. The small occipital nerve ramified over the surface of this last muscle supplying the integument in this region, but giving no branches to muscle. It is well known that nerves of supply to muscles situated superficially enter their deep surfaces, and this fact also tends to show that the small occipital cannot be the nerve of supply to the occipito-frontalis. The small occipital nerve, therefore,

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[1] 7th edition, by Sharpey, Allen Thomson, and Cleland, p. 612.

[2] *Demonstrations*, 6th edition, p. 8.

(along with all the other branches of the superficial cervical plexus) is to be looked upon as a nerve purely sensory in its function and distributed to integument.

Great Auricular Nerve.—The facial or anterior branches of this nerve appear to have a more extensive distribution than is generally ascribed to them, viz. the supply of the integument over the parotid gland. In the dissection I made of this nerve these branches were five in number and had the following distribution: (*a*) the most anterior and inferior pursued a course almost parallel with and about three-fourths of an inch above the inferior margin of the horizontal ramus of the lower jaw, and reached a spot about half-an-inch from the mental foramen. (*b*) The most posterior branch proceeded almost vertically upwards to a point about one inch from the outer angle of the eye, and was there lost. (*c*) The intermediate branches passed upwards and forwards towards the angle of the mouth and malar bone and ended about one inch from these. In their course these branches gave off numerous twigs to the skin in this region.

Practically speaking, therefore, these branches supplied the integument over the parotid, masseteric and buccal regions of the face. Mr Kirkwood confirmed this dissection on the opposite side of the body.

ON SPHYGMOGRAPHY. Part II. By A. H. Garrod, B.A., *St John's College, Cambridge.*

In endeavouring to form a correct estimate of the significance of the various details of the sphygmograph trace, it will be necessary to enter somewhat minutely into the consideration of each of the several mutually related forces which, by their combined action, produce the resulting curve. As some of these forces are but little understood, it is clear that any attempt to explain the pulse movements by arguments deduced from tracings obtained from a 'schema' of the circulation, can only be of value, as far as they relate to forces acting on the 'schema' which are strictly comparable with similar forces at work in the human body. This consideration has prevented my basing any deductions on facts derived otherwise than from the animal body itself.

To commence with, it will be necessary to describe the tracings obtained by means of the 'Hæmadromograph' of Chauveau. Dr Lortet, of Lyons, has given an excellent figure and description of this instrument[1], which, from its simplicity and efficiency, is a perfect masterpiece of mechanical design. By means of two levers it indicates on a revolving drum both the modifications in the diameter of an artery during a pulse-beat, and also the changes in the velocity of the blood-current at the same spot, simultaneously. The former of these results is obtained by the use of an ordinary sphygmoscope, an instrument which measures indirectly the modifications in the area of an artery; and the latter by a long lever which, at its attached end, after passing through a slit in the side of the tube, projects a short distance into the vessel, which allows of its being moved backwards and forwards by the blood-current.

The accompanying trace (Fig. 1), taken with this instrument from the carotid of the horse, is copied from Dr Marey's work[2].

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[1] *Recherches sur la Vitesse du Cours du Sang dans les Artères du Cheval.* Par M. L. Lortet, M.D. *Annales des Sciences Nat.*, Tome VII. Zoologie. 1867. An earlier but very similar instrument, by M. Chauveau, is described in Marey's *Physiologie Médicale de la Circulation du Sang.* 1863, p. 156.

[2] *Loc. cit.* p. 273.

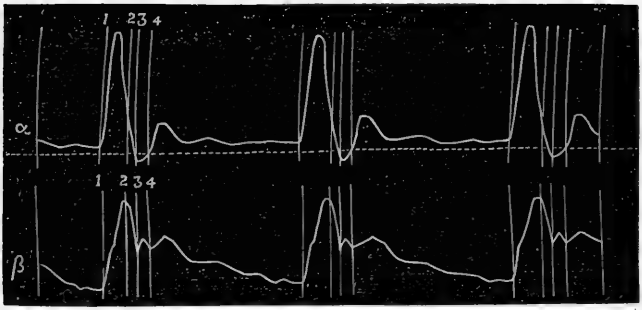

Fig. 1. Hæmadromograph trace from the carotid of the horse.

a. The current trace, in which the horizontal dotted line is the zero, indicating no current in either direction.

β. The sphygmoscope trace.

In both, the vertical line 1 cuts the curve at the commencement of systole, the line 3 at the moment of closure of the aortic valve, and the line 4 when the centrifugal current recommences.

The figure reads from left to right.

The upper curve (*a*) is that of the blood-current; in it the horizontal dotted line indicates the zero, or line of no current in either direction; all above shews a centrifugal current, and all below an heartward stream. The velocity of the blood's movement is measured by the distance of the point which is under consideration from the zero line in the trace. The lower curve is that obtained by the sphygmoscope, and is in all respects strictly comparable with an ordinary sphygmograph tracing. The slightly curved vertical lines which intersect both tracings are drawn by the levers when the watchwork is at rest, and the points where similarly situated lines intersect the pulse traces are exactly simultaneous, to indicate which they are drawn. With regard to these figures, Marey makes the following observations:—"I. The commencement of the pulsation coincides with the production of a rapid centrifugal current. II. The summit of the pulsation is not reached before the centrifugal current has already ceased. III. At the instant of closure of the sigmoid valves, a retrograde current is flowing in the carotid, as indicated by the position of the curve, which at that moment is below zero. IV. After the closure of the sigmoid valves a fresh centrifugal current originates, which constitutes the secondary pulsation—(dicrotism)." Dr Lortet explains the portion of the upper or current-trace which is below the zero line, by supposing that the shock of closure of the sigmoid valves is sufficiently great to produce a stretching of the proximal end of the aorta and of the valves themselves, which results in a retrograde current for a short time in the large arteries after the valves have closed. Marey's explanation, as far as it goes, seems much more satisfactory, and it will be necessary to discuss it more fully. Before doing so the precise definition of some of the terms employed will not be out of place. The main rise in the sphygmograph trace may be termed the *primary* rise, and that which occurs just after the small rise and fall which is nearly simultaneous with the sinking of the current-trace below the zero, and which therefore commences with the secondary centrifugal current, may be termed the *secondary* rise; it is almost always very clearly indicated in sphygmograph tracings (c. *a* Fig. 2). The interval between these two rises may be called the *sphygmosystole*, for it is the time during which

Fig. 2. Sphygmograph tracings, all taken from the same individual in health, under different conditions, to shew the effect of difference in pulse-rate on the trace.

a.	Pulse-rate	44	in a minute.
β.	... ...	63	... ...
γ.	... ...	72	... ...
δ.	... ...	103	... ...
ε.	... ...	137	... ...
ζ.	... ...	172	... ...

They are all drawn on one scale and read from left to right.

the systole at the heart influences the pulse-beat; it corresponds to the *first* part of the pulse-beat in my former communications, and it must be remembered that it is not synchronous with the cardiac systole, as I have endeavoured to shew elsewhere[1].

From a study of tracings obtained by the use of the cardiosphygmograph, I have demonstrated, in the paper just referred to, that in the sphygmograph trace of slow pulses, the closure of the aortic valve occurs when the lever is at the lowest point of the notch that is nearly always present in the sphygmosystole, which is also clearly seen in the lower of the two tracings in Fig. 1, the curved line 3 cutting it exactly at the place which represents the moment when the valve shuts. Consequently, in the upper trace, the line 3 must also cut it at the same time, and this occurs when the retrograde current is at its maximum, as would be expected, the valve being closed by the regurgitating blood. But it may be asked, how is it that the backward current between the lines 3 and 4 in α Fig. 1 is associated with a rise in the sphygmoscope trace? and to explain this clearly, it will be necessary to refer to some of the elementary principles which operate in the transmission of currents through elastic tubes. First, it can be demonstrated that increase in the diameter of an artery may originate from two quite independent sets of causes, one being the simple result of the heart sending more blood into it in a given time than it can dispose of; the other being a shock-expansion, comparable with the waves of condensation and rarefaction in the air, which constitute sound. Most of the important elements of the pulse-trace are referable to the former of these causes, as is proved by the general similarity between the two curves α and β, in Fig. 1. But when there are rises in the second, which are quite independent of changes in the first, they must evidently be the result of some sudden movement in the circulating system, originating a shock, which is not of a character to affect the current in any way. It is but reasonable to suppose that such should occur as a result of the closure of the semilunar valves, and the rise and fall between the vertical lines 3 and 4

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[1] *Proc. Roy. Soc.* 1871, p. 318 et seq., and *Journal of Anat. and Phys.* May, 1871.

in the lower trace (β) of Fig. 1, commencing immediately on their closure, and being unconnected with any current changes, can be nothing else than a shock-wave.

At first sight it would seem probable that when the semilunar valves had closed, the retrograde current in the aorta would immediately cease; but that such is not the case is clearly proved by the continuance below the zero line of the current curve, for a short period after that event (between the lines 3 and 4 in the upper trace). It is by the combined operation of two causes in the same direction that this result is produced. First, the orifices of the coronary arteries being quite close to the semilunar valves, it is evidently necessary that the blood which enters them during diastole must be derived from the aorta, and so tends to produce in it a retrograde current. Secondly, the equilibrium of the arterial system is disturbed during the closure of the aortic valve, for immediately the systole has terminated, the only force tending to prevent the blood from regurgitating into the heart, is the statical resistance of the ventricular walls, which at that moment are closely approximated, causing their cavities to be completely obliterated. This resistance is clearly much less considerable than that offered by the heart-walls during the systole, one being a statical and the other a dynamical condition; consequently the arterial blood rushes back, pushing asunder the ventricular walls, and in so doing, developing a sufficiently rapid retrograde current to close the semilunar valves. The interval thus arising, namely the time between the end of systole and the complete closure of the aortic valve, I have called the *diaspasis*, in a pamphlet on "the Law which regulates the frequency of the Pulse[1]," and there is considerable evidence to shew that when the pulse-rate does not vary it is constant; also that it varies very slightly with different frequencies of heart-action, occupying in slow pulses about 0·002 and in quick ones 0·0018 of a minute[2]. The diaspasis is so short in

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[1] Published by H. K. Lewis, 139, Gower Street, London.

[2] In my pamphlet on *The Law which regulates the Frequency of the Pulse*, from a mistake on my own part, a statement is made as to the length of the diaspasis, which is incorrect. Mathematical friends soon informed me of my error, as, when precisely stated, the problem is a manifest contradiction. In p. 22 the diaspasis is discussed, and in the summary of the results arrived at,

duration that it has terminated before the loss of blood from the proximal aorta into the heart is made good by any retardation of the onward current, or a reverse stream in the more distant vessels originates; consequently this restoration of equilibrium has to be in great measure effected after the valves have closed, encroaching on the diastole to form the second cardio-arterial interval of the cardio-sphygmograph trace, which does not cease until all the complications attending the closure of the semilunar valves have come to an end, whereupon the again augmenting centrifugal current, or in very low-tensioned pulses, such as that figured in Fig. 1, the diminishing centripetal one, originates the secondary rise in the sphygmoscope trace.

In both the primary and secondary rises of the pulse-beat (Fig. 1), it is found on inspection that the summits of the pulsations (β) are delayed upon, or are not reached so soon as the centrifugal current maxima (a); and that such should be the case is essential, in a circulation maintained by an intermittent

in p. 27, the following are given as the relations of the lengths of the various elements of the pulse-beat to one another.

1. The systole together with the diaspasis, or, in other words, the first cardiac interval varies as the square root of the whole revolution.
2. The systole varies as the square root of the diastole.
3. The diaspasis is constant.

The incompatibility of these three statements it is not difficult to prove, for if the first and second are true, the third cannot be so, and, as a fact, the diaspasis is *not* constant. There is every reason to believe that for a given pulse-rate the diaspasis does not vary; and, on subtracting its length, as obtained by measurement in quick cardiograph tracings, from the first part of slow ones, I found that the remainder, the systolic interval, varied *very nearly* as the square root of the diastolic. On repeating the operation on the pulse of intermediate rapidity a similar result was obtained, and the error, being extremely small, I attributed it to my not having extracted the necessary square roots to a sufficient number of decimal places, and thus felt justified in making the generalization given above. Since the mistake has been pointed out to me I have repeated the arithmetical computations more carefully, and find that what I had first supposed were errors on my part, are constant variations, which prove that, the other statement standing as above, the diaspasis is slightly longer in slow pulses, occupying approximately 0·002 of a minute in a pulse of 61, and 0·0018 of a minute in a pulse of 152 in a minute. This fact, therefore, leads to the conclusion that the rapidity of the fall of blood-tension has an influence on the length of the diaspasis, lengthening it slightly when the tension-fall is retarded, probably because the previous systole is then more powerful and gradual. It is to be noted that the second cardio-arterial interval of cardio-sphygmograph tracings is almost of the same length as the diaspasis, and varies in the same or in a very similar manner, which may be the cause of the somewhat undecided nature of the notch in the sphygmosystole of slow pulses. From these remarks it is necessary to substitute for statement 3, as given above, the following: 3. The diaspasis varies, being slightly longer in slow pulses.

motor organ, which, like the heart, rests between its pulsations; for after the rush of blood into the arteries immediately the sigmoid valves open, during the rest of the systole the blood which leaves the heart is employed in retaining the higher pressure in the vessels, as will be explained more fully further on.

We are now in a position to consider the human sphygmograph, tracing from the wrist, and on looking at Fig 2 (*a*), which is from a slow pulse, it is evident that in all respects it closely resembles that taken with the sphygmoscope from the carotid of the horse, which has been discussed above, and there is every reason to believe that the details originate from similar causes. The primary rise (*a*) is followed by a gentle fall; this is soon broken by the shock-wave (*b*) consequent on the closure of the aortic valve, and is followed by the secondary rise (*c*), which commences when the centrifugal current is augmented by the recommencing onward current in the aorta. The sphygmodiastole is remarkably uniform and uninterrupted.

Between the tracings of slow and quick pulsings there is at first sight not much resemblance, but it is not difficult to obtain a series between them exhibiting every intermediate condition (Fig. 2, α, β, γ). The most important cause of the variations exhibited by pulses of different rapidities, is that the ratio between the length of the sphygmosystole and the sphygmodiastole is not constant. For instance, when the pulse is 114 a minute, the sphygmosystole occupies just one half the beat; but when it is 40 a minute, it only occcupies one quarter of the whole revolution. It is evident that this must influence the general appearance of the trace, and as the length of the sphygmosystole never varies in health for any given pulse-rate[1], a knowledge of the ratio of the length of sphygmosystole to that of the whole beat is sufficient datum for determining the pulse-rate. In the paper just referred to I have given several measurements of these ratios, and have shewn that the length of the sphygmosystole maintains a very definite relation to the length of the beat, varying as its cube root, consequently when

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[1] *Proc. Roy. Soc.* No. 120, 1870.

the length of the revolution increases in the series 1, 8, 27, 64, &c., the sphygmosystole only does so as 1, 2, 3, 4, &c., so that if we call the rapidity of the pulse x, and the number of times that the sphygmosystole is contained in the beat y', the length of the sphygmosystole can be found from the equation

$$xy' = 47 \sqrt[3]{x}.$$

Further, the cardio-sphygmograph[1] shews that the interval between the closure of the aortic valve and the commencement of the secondary radial rise (the second cardio-arterial interval) varies but little with different pulse-rates, while that between the primary radial rise and the closure of the aortic valve (the conjugate cardio-arterial interval) does so much more rapidly, both being longer in slow pulses. This also greatly influences the appearance of the pulse-trace, for, as previously shewn, the small rise and fall at the end of the sphygmosystole results from the shock of closure of the aortic valve, and as this occurs in slow pulses an appreciable time after the primary rise has reached its maximum, it is clearly seen as a separate element of the curve. But in quick pulses, the second cardio-arterial interval is nearly as long as in the slow ones, while the conjugate cardio-arterial interval is much shorter, consequently the shock-rise and fall following the aortic valve closure is thrown back, as it may be termed, on the primary rise, and being blended with it, is not separately distinguishable. This is the cause of the simplicity in the sphygmosystole of quick pulses.

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[1] *Journ. of Anat. and Phys.* May, 1871.

THE EFFECT OF EXERCISE ON THE BODILY TEMPERATURE. By T. CLIFFORD ALLBUTT, M.A., M.D., Cantab., F.L.S.

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FOR some years past I have been engaged upon the interesting study of the temperature of the human body in health and disease, and I have summed up certain results of my experience in articles in the *Medical Chirurgical Review* and elsewhere. In estimating these results, it is found to be of the greatest importance to the enquirer, to have a satisfactory basis for comparison, and such a basis or standard, we think, we have in the temperature of the healthy body. It becomes, therefore, a primary duty to settle as firmly as possible, the limits of fluctuation in health, and the effects of various external conditions upon these fluctuations. Many observers, among whom I may name the late Dr Davy and Dr William Ogle, have laboured hard in this matter, and we have had the satisfaction of seeing that the regulating power of the organism is so perfect that external conditions have but little effect in disturbing its ordinary periods. In summing up, however, I found that the effects of hard and prolonged exercise upon the body had not been tested, and this seemed a serious omission.

When we consider the great mechanical work performed by the body in muscular exertion, and the molecular change correlative with it, we might well expect to find that force diverted in this way might leave a great deficiency of heat. The marvellous regulating power which the human body has been shown to possess, may, or may not, be able to make up for this outgoing by increased combustion within. All our present experience, however, would lead us to look for this. When we see that plunging into cold water, by driving more blood through the lungs, and other viscera, makes up for the abstraction of heat; when we find, as I and others have found, that exposure to heat of 300° F., on the other hand is neutralized by evaporation from the surface and lungs, the body preserving in both instances its normal temperature; when we consider its resistance, I say, to cold and heat, to any interference with function which is not actually mischievous, and to many like serious disturbances, we gain so great a faith in this capacity for self-regulation, that we expect it to meet the strain of hard exercise with like success, unless the strain be beyond the powers of the individual. When we initiate a state of disease, we shall of course look for perturbation of the temperature curves, but knowing what we do, we should scarcely look for perturbation of the curves to any marked extent so long as the muscular exertion used did not exceed that quantity which the body seems built for. Such were the opinions I held in starting for Switzerland this summer[1], but I felt I could not take the uniformity of the curves for granted until I had submitted them to the test of repeated experiments, so that I made these experiments one of the main objects of my tour. Unfortunately, the weather was so unpropitious, that we were prevented from making high excursions. I think, however, that we were able to do work enough to test fairly the effects of it upon the body. When I began my observations I was unaware that experiments of the same kind had been carried out. However, Mr Ray Lankester, whom I met by chance near Martigny, told me that M. Lortet of Lyons had made two ascents of Mont Blanc for this purpose, and that he reported great depression of temperature as his results.

I had been walking for a few days when I heard of this, and had made complete observations for two days. Two days afterwards I met a Swiss gentleman at Chamouni, who placed in my hands M. Lortet's *Deux Ascensions du Mont Blanc en* 1869: *recherches physiologiques sur le mal des montagnes,* par M. L. Lortet, 1869. I shall refer again to M. Lortet's results after reading my own. Dr William Ogle makes some allusion to the effects of exercise upon the body, and states, in opposi-

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[1] This refers to the summer of 1870. In the summer of 1871 the weather enabled me to take some higher excursions, but I only made a few isolated thermometrical observations, which presented nothing contradictory. As regards the observations now published, I have to say that although these probably represent all that were carefully made, yet, on the other hand, the thermometer was rarely out of my mouth in the intervals during the day-time, so that the movements of the mercury were constantly controlled. Of course this added no little to the exertion of walking.

tion to M. Lortet, that it has the effect of elevating the bodily temperature: but Dr Ogle does not appear to have investigated the matter on a large scale. Before setting off on my journey I had been engaged for some months in studying my own temperatures under all sorts of changing circumstances, so that I had become thoroughly familiar with the variations of my own body. I here append an average scheme of my own bodily temperature, which represents the average of the curves under ordinary circumstances, taken hourly on twenty-five separate days.

Average of 25 *days at various dates noted during the earlier summer of* 1870 *for the purpose of the subsequent investigations. My ordinary habits give me but little physical exercise. I breakfast at* 8.30, *lunch at* 1.30, *and dine at six. No temperatures were taken in bed. The gradual curve contrasts strongly with the sharper curves taken in Switzerland.*

AVERAGE OF ORDINARY TEMPERATURE.

HOURS.	TEMPERATURES.
Between 7...10	97.8
Between 10...12	98.2
Between 12...2	98.4
Between 2...4	98.5
Between 4...6	98.6
Between 6...8	98.7
Between 8...10	98.5
Between 10...12	98.2

August 7, 1870. BEX TO LES PLANS.

HOURS.	CONDITIONS AS REGARDS EXERCISE.	TEMPERATURES.
9.30 A.M.	At Bex. After breakfast	97.8
11.30 ...	An hour on the walk to Les Plans	98.2
12.10 P.M.	Still walking, Sun very hot..................	99.2
3.30 ...		99.4
5.0 ...	Walking on slopes. Continuous walking all day with but little food...............	99.3
7.10 ...		99.1
8.30 ...	After supper: at Chalets	98.8
9.15 ...	On going to bed	97.8

August 8, 1870. DENT DE MORCLES.

HOURS.	CONDITIONS AS REGARDS EXERCISE.	TEMPERATURES.
3.0 A.M.	In bed	97.5
4.45 ...	Up. Before breakfast	97.5
5.30 ...	After breakfast. Before walking	97.7
6.30 ...	After an hour's quick walking	98.6
8.30 ...	Walking	98.9
9.0 ...	After sitting without coat in cold breeze for 15 minutes	98.5
10.30 ...	Sitting on Col, after some food	99.2
12.30 P.M.	Standing about. Exercise moderate	99.0
3.0 ...	Walking home quickly. Near Les Plans	99.2
6.0 ...	At Les Plans. After rest. Before dinner	99.2
8.30 ...	After an hour's evening walk	98.1

August 9, 1870. LES PLANS TO MARTIGNY.

8.15 A.M.	Walking about (20m. or so) before breakfast	98.4
9.15 ...	After breakfast	98.6
12.0 ...	Walking down to Bex from Les Plans	98.8
2.30 P.M.	Near Bex. Walking	99.1
4.30 ...	Near Martigny. After 4hrs. sharp walking. Wet through	99.2
10.0	In bed. (Dined at Martigny 6.30)	97.8

August 10, 1870. MARTIGNY TO CHAMOUNI.

6.30 A.M.	In bed at Martigny	97.5
7.30 ...	After breakfast	97.8
9.30 ...	Walking. Day hot	98.8
10.45 ...	Ascending steep slopes under hot sun ...	99.2
12.30 ...		99.2
2.30 P.M.	After rest and lunch at Barbarine	99.0
4.30 ...	Walking for two hours	99.2
5.30 ...	Walking through Argentière	99.0
8.30 ...	After dinner, before retiring at Chamouni	97.8

August 11, 1870. PLAN DES AIGUILLES.

9.0 A.M.	Before starting for Plan des Aiguilles ...	97.8
10.30 ...	Walking briskly up steep ascent. Wet through	98.5
2.0 P.M.	In Chalet. After food and rest	98.7
4.0 ...	Walking down to Chamouni. Nearly at bottom	98.8
7.30 ...	At rest in Chamouni. Dinner at 6.0 ...	98.6
9.30 ...		97.9
	This day was of cold drizzling rain.	

August 12, 1870. CHAMOUNI TO TRÉLATETE.

HOURS.	CONDITIONS AS REGARDS EXERCISE.	TEMPERATURES.
8.30 A.M.	Chamouni. After breakfast	97.8
10.30 ...	After walking nearly two hours. St Gervais Road..................................	98.8
12.30 ...	Walking to St Gervais	99.1
2.45 P.M.	At Mont Joli Inn	99.2
4.30 ...	Walking to Contamines	99.2
7.0 ...	Ascending steep slopes above Contamines. No sense of feverishness or of much thirst	100.0
8.30 ...	Before bed at Chalets	97.8
	This day was very hot. Knapsack carried.	

August 13, 1870. PASS OF MONT TONDU.

3.30 A.M.	On rising from bed	97.5
5.30 ...	Ascending towards Col Trélatête. On glacier	97.9
7.0 ...	Thermometer removed on reaching Col...	98.2
9.0 ...	Approaching Motet. Here breakfasted and rested 1½ hour	98.6
12.0 ...	Reaching summit of Col de la Seigne......	99.1
3.0 P.M.	In Allée Blanche............................	99.1
5.0 ...	Entering Cormayeur	99.1
8.30 ...	In Cormayeur. After a cold bath and dinner	97.8

August 14, 1870. CORMAYEUR.

9.30 A.M. 11.30 ... 2.0 P.M.	Idle all day at Cormayeur until 3.30, when we started for the pavilion on Mont Frety	98.2 98.4 98.8
5.30 ...	Taken while on ascent. Cool evening ...	98.9
9.0 ...	Taken just when retired to bed. Supper with wine about 6.30	97.5

August 15, 1870. COL DU GÉANT.

2.0 A.M.	Before starting. Before food. At Mont Frety	97.3
5.15 ...	On top of Col du Géant	98.0
12.0 Noon.	On Mer de Glace. After difficult descent of seracs	98.6
3.0 P.M.	At Montanvert after long rest, food and wine	98.8
6.0 ...	Entering Chamouni..........................	98.6
9.0 ...	Retiring to bed	97.3

August 16, 1870. CHAMOUNI.

HOURS.	CONDITIONS AS REGARDS EXERCISE.	TEMPERATURES.
9.0 A.M.	Coffee at 7.30. Taken while at rest......	97.8
11.0 ...	After breakfast with omelette. No wine	98.2
2.30 P.M.	After slight lunch	98.4
5.0 ...	Day occupied in lounging about the district	98.7
8.0 ...	Dinner, with wine, at six	98.5
9.30 ...	Before retiring to bed	98.0

August 17, 1870. GRANDS MULETS.

8.15 A.M.	Just before leaving Chamouni. After breakfast	98.4
10.0 ...	Approaching Pierre Pointue. Walking steadily....................................	97.4
11.0 ...	After breakfast with meat, wine, and rest	99.2
12.0 ...	On way to Grands Mulets	98.0
1.30 P.M.	" "	96.3
3.0 ...	Just reaching the Grands Mulets	95.5
3.15 ...	Seated for ten minutes in cabin	98.5
4.15 ...	Grands Mulets. After rest and food......	99.0
6.15 ...	" " Just before bed	99.1
	The temperatures all through this day very curious and disorderly.	

August 18, 1870. MONT BLANC.

1.30 A.M.	At Grands Mulets. Before rising from bed	97.5
3.30 ...	Walking on Mont Blanc, since 3 o'clock	97.7
5.0 ...	" " "	98.0
7.30 ...	Descent commenced soon after 7 o'clock .	98.5
8.30 ...	Descent to Mules, 5 min. from destination	98.5
10.30 ...	Walking to Pierre Pointue (just starting)	98.6
12.30 P.M.	Approaching P. P., arrived as instrument removed	98.0
1.30 ...	At P. P., and after a meal with meat, &c.	98.7
2.30 ...	On way to Chamouni	98.9
3.30 ...	" "	98.9
5.0 ...	At Coutet's Hotel and after cold bath ...	98.9
9.15 ...	" " and turning into bed..	97.6
	This was a day of very severe weather, and great exertion, owing to the state of the ice and of the snow. The temperatures were disorderly about noon.	

August 19, 1870. CHAMOUNI.

HOURS.	CONDITIONS AS REGARDS EXERCISE.	TEMPERATURES.
9.0 A.M.	After breakfast—without wine	98.5
12.0 ...		98.8
	Lunched at 1.30	
3.0 P.M.		99.2
	Dined at 6.	
9.0 ...	On retiring to bed	97.5
	Poured with rain all day; we were kept to the house entirely, or nearly so.	

August 20, 1870. CHAMOUNI TO GENEVA—By Carriage.

5.30 A.M.	Before rising from bed	95.4
6.30 ...	After breakfast—without wine. After breakfast sharp diarrhœa. Two evacuations	95.4
10.30 ...		97.8
12.30 P.M.	In carriage going to Geneva, and walking about Geneva	98.5
3.0 ...		98.8
5.30 ...		98.8
9.0 ...	Bed. Dinner with wine at seven	98.1

The schemes of temperature which I shall now exhibit are those taken while walking. My friend, T. S. Kennedy, and myself, met François Devouassoud at Bex, on August 6th, 1870, with the intention of walking on the high Alps. The weather was very unsettled. On the 7th we commenced our walk. I walked generally without a knapsack, and weighted only with a heavy pair of boots and an axe. The thermometer I used was obtained from Messrs Harvey and Reynolds before starting: it was specially selected and tested. The instrument had an index, and in the majority of cases the observation was made by placing the instrument under the tongue, with the usual precautions, leaving it in situ for 15 or 20 minutes, and then noting the position of the index, the hour of its removal being noted at the same time. The observation was always taken while we were in motion, except in cases when the contrary is stated. On many occasions, however, I watched the thermometer while in place, and this I was able to do very easily with a small pocket mirror. I did not find any reason, however, to distrust the results of the index. As to the length of time of insertion, I have to say here the contrary of what I say in common clinical observations. In these a few tenths, more or less, make no matter, and we have much more cause to fear that medical men will shrink from the delay of long insertions, than that an insertion of four minutes will deceive them. In physiological research, however, one or two tenths is of great importance, and I have often found, both abroad and at home, when watching the instrument in place, that ten minutes was an insufficient time for the completion of a rise. I have often seen the mercury rise two-tenths after ten minutes of insertion. On the 7th of August we walked up from Bex to the Châlets of Les Plans; we started about ten A.M., and as we extended our walk considerably by collateral excursions upon the slopes, we did not reach the châlets till late afternoon. The day was fine and very hot. On reference to the table it will be seen that my temperature rose to 99.4 at 3.30 P.M., the highest temperature but one that I recorded. On the 8th we started at 3.0 A.M., from the châlets, with the intention of ascending the Dent de Morcles. The weather was misty and chilly all day. On rising at 3.0 I found the temperature at 97.5, and this temperature I found to be my invariable night-temperature throughout. At 4.0 the temperature was the same and at that hour we breakfasted. At 4.45, after breakfast, the temperature had risen to 98.2. At 5.0 we started, and at 6.30 the exercise had brought up the temperature to 98.8, an unusual height for so early an hour. At 8.30 I registered the same, and then being hot I purposely removed my coat and sat on an exposed stone in the chill air for 15 minutes, during which time the instrument was replaced. On removal it registered 98.5, but I am not certain whether the drop was due to the coolness or to the cessation of exercise or both. At 10.30 we had crossed the glacier and reached a depression just under the summit. My temperature on reaching it was 99.2, and I may say 99.2 was a constantly recurring number, and seemed, exceptions apart, to represent the regular temperature during the noon and afternoon when in exercise. This temperature was often reached at 11 or 11.30, and persisted till about 5.30 or 6.0 P.M., when the fall set in. Under ordinary circumstances my temperature rarely exceeds 98.6 at any time of the day and seldom attains that until the early afternoon. On this day at 6.0, just before dinner, the evening fall had commenced, the note being 98.6.

We did not reach the summit of the peak, as the mists were around us, and we were unable to discover the way up the very ugly looking rocks at the last. I suppose we reached a height of about 9000 ft., the rise being a somewhat rapid one. The badness of the weather now broke up our plans of ascending the Diablerets and running down the Sansfleuron Glacier to Lauenen. We were driven down the valley and walked to Martigny. On this day, the walking being easy and down hill, my temperature did not reach 99.2 till 4.30, the day however was cold and wet.

August 10 was a hot day with a good deal of sun. We set off intending to walk by the new route to Chamouni, but as some mining operations were going forward, we passed up some very steep slopes as high as Salvent and dropped down upon the new route opposite to the Tête Noire Tunnel. The hot day and quick ascent brought me up to 99.2 at 10.30 in the forenoon. At 6.30, between Argentière and Chamouni, the evening being cool, I registered 98.8. [Not given in curve.]

August 11. Day chilly and foggy with light and heavy rains. Walked in rain up to the base of the Aiguilles, coming home by a détour. Although the ascent was somewhat rapid my temperature on this day never exceeded 98.7. I was wet through most of the day.

Aug. 12. Day very different to yesterday, not very clear on heights but soon bright and hot. The difference between this day and the day before in temperature is remarkable, the highest range being exactly 100°; we left Chamouni at 8.30 and walked to the Mont Joli inn at St Gervais. From thence we walked to Contamines, and it was in ascending some rather steep slopes from here to the Châlets of Trélatête, that I found my temperature 100°.

Aug. 13. A moderately fine day, not very hot. We traversed the Mont Tondu pass and the Col de la Seigne. Temperature at starting (4.0 A.M.) was 97.5 and rose steadily till 2.30, when it was 99.2. At this height it remained till 7 P.M. when it fell gradually to 98.5 on retiring to bed at 9 o'clock.

Aug 14. Idle all the morning at Cormayeur. At three o'clock went up to the pavilion on the M. Frety. The rise, which is tolerably steep and takes about two hours, had no effect upon the temperature. At 9.0 it had fallen to 97.5 after about two hours of rest and food.

Aug. 15. Crossed the Col du Géant. Day fine but cool. Temperature steadily rose all day, reaching its height at 3 P.M., which was 98.8, we had then been long at rest at the Montauvert. On the top of the Col at 5.15 A.M. it was 98.0.

Aug. 16. Idle all day in and about Chamouni.

Aug. 17. Set off for the Grands Mulets with intention of ascending M. Blanc. On this day I noted two very curious falls of temperature, like those noted by M. Lortet, and I noticed them on this day and the next only. The first was at 10.0 A.M., on approaching Pierre Pointue, when the temperature fell to 97.4 from 98.4. It rose to 99.2, at the pavilion, after an hour's rest and breakfast with wine, &c. At 12.25, when about halfway to the Mules, it had again fallen to 98.0, and when reaching the Mules the mercury had fallen to 95.5, two degrees lower than I had before noted. On sitting down at the Mules I again inserted the instrument for 15 minutes and found it to be at 98.5. At 4.15 it registered 99.0, and at 6.15, 99.1. Shortly after this we went to bed.

On Aug. 18 the day was unpromising. At 1.30 on starting my temperature was 97.15. I took continuous observations upon the mountain, the temperature slowly rising. At the Grand Plateau it was 98.0 exactly. The weather now became more and more threatening, the wind rose, snow began to fall, and we had to contend with that kind of snow underfoot which has a crust just too weak for support and which suddenly lets the voyager 18 inches or more down at each step. Reluctantly we felt obliged to return, and at 10.30, on leaving the Mules for Pierre Pointue, I registered 98.6, which was above the average of that hour on ordinary days at home[1]. At 11.30 the tem-

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[1] This represented a very hard day's work, probably much harder than a complete ascent in fine weather.

perature had fallen to 98.3, and just before reaching the Pierre Pointue (12.30), it was down to 98.0. After rest and refreshment, I found it at 1.30 to be at 98.7, and at 2.30, when walking down to Chamouni, it was 98.9. This temperature remained steady for the rest of the day. The weather was cool, rather chilly, and some rain. I was not particularly fatigued.

Aug. 19. Rained steadily all day. Temperature at 3.0 P.M. 99.2, and at 9.0 on retiring to bed was 97.5, shewing the effect of the exercise the day before in enlarging the curve.

Aug. 20. The weather being still bad I determined to leave for England. Before rising (at 5.30) I was surprised to find the temperature down to 95.4, and there it remained after breakfast (at 6.30 o'clock). I then found myself suffering from a sharp diarrhœa. It passed off quickly, and at 12.30, when in the diligence for Geneva, I had risen to 98.5.

Such are the observations I made, and from them I draw the following conclusions:

1. That setting aside the exceptional results of Aug. 17 and 18, the tendency of exercise was to raise my temperature. This was seen not only at the time of climax but also in the earlier commencement of the forenoon rise. This conclusion is strengthened by the four observations which I made upon Mr Kennedy during steady walking. Each observation was made about noon or soon after, and 99.2 was registered on each occasion.

2. That this rise was compensated by the earlier occurrence of the evening fall, which had often reached the night level of 97.5 at 9 o'clock in the evening. This also occurred Aug. 19, at rest all day. I found this to be the register of all the night hours I took, save on the one night preceding the diarrhœa, when it fell to 95.4.

3. Weather had some influence upon the temperatures. On hot days, when walking, I reached 99.2 almost invariably, on cool or chilly days I commonly fell short of 99.0.

4. To turn to the exceptional day, Aug. 17. On this day and the next my temperature fell quickly and twice over during exercise, as though the mechanical work done were more than combustion could compensate. This brings me to the considera-

tion of M. Lortet's observations, with whom the two exceptional events of mine seem to have been a constant occurrence. M. Lortet seems to have had a trustworthy instrument and to have used it very carefully. He says, "While walking, the decrease of the internal temperature of the body is very remarkable, *it is almost proportional* (the italics are his) to the height at which one is." From the table given "one may state that during the muscular effort of ascent the bodily temperature may fall, when one is climbing from 3500 ft. to 15,000 ft., four and even six degrees centigrade, an enormous fall for mammals whose temperature is said to be constant." "The moment one stops for a few minutes the temperature quickly reascends almost to the normal figure." M. Lortet goes on to eliminate any possible accidents, such as cold breezes, &c. &c., then says that his observations are equally true for small altitudes, for he was able to obtain the same results in a less degree by ascending small elevations near Lyons. M. Lortet adds that these results are not true for the hour which follows a meal, and partly explains this by supposing that the food serves as extra fuel to meet the excessive demand. The rest of his chapter is occupied by the reasoning which attributes the loss of temperature to the transference of a given quantity of heat to a given quantity of muscular effort, &c., estimating the value of a man's position at so many feet above the sea level, and so on. Now I have to say, in the first place, that except on the day stated, I never observed this diminution of temperature, but rather the reverse.

On the following day, Aug. 18, there was a recurrence of a like phenomenon, but it will also be seen that at that time I was actually descending not ascending. I was just completing the easy descent to Pierre Pointue, a distance of 3500 ft., or nearly so. On Aug. 17, however, when the diminutions were certainly remarkable, I may further point out that one of them (12.0 noon) took place an hour after the ingestion of a good meal with meat and wine.

It is difficult to see how the mere presence of food in the stomach can help heat developement; one reason given by M. Lortet is, that it probably "accelerates the capillary or general circulation." Unfortunately, a page before he adduces the acceleration of the circulation through the lungs in ascending as a cause of imperfect lung-combustion and consequent cooling. Food in the stomach may perhaps act as a cordial, and so strengthen the impulses of the heart, but with this we should have a less frequency of action. Now how it is that M. Lortet's temperature behaved so irregularly on both his ascents, and mine also during one very moderate climb by a mule path to the Pierre Pointue, is hard to say. It is touching upon delicate ground to compare the relative powers of our organisms, but I must say that there are one or two points in M. Lortet's experience which suggest some difference of this kind. M. Lortet took a sphygmograph up M. Blanc, though I cannot conceive how he could use it on the slopes with any accuracy. However he gives several tracings, and these seem to shew a very serious interference with his circulation. The pulse seems to have been extremely rapid and small, and the arteries to be almost empty. The pulse curves to me seem indeed to be pulses of collapse. Even on the following day at Chamouni, M. Lortet's pulse shewed a very irregular trace, a trace which would make me uneasy if it occurred in my own person. Now I had no sphygmograph, and here M. Lortet has the advantage of me, but I am perfectly satisfied that my pulse was never irregular, that it was never very small, and that it never exceeded 128, seldom indeed 120. Certainly I did not reach the summit of M. Blanc, but I am now comparing my own state on the Grand Plateau with that of M. Lortet at the Mules. It seems to me that M. Lortet's temperature behaved in some exceptional way when he ascended M. Blanc, in a way which is unexplained, but which I also noticed on one day when walking up to the Pierre Pointue and the Grands Mulets, and which seemed to have some little tendency to remain with me on the following day, when not ascending but descending from the Grand Plateau to the Mulets. On the Dent de Morcles, on the Mont Tondu, on the Col du Géant, and in my lower walks, I never noticed the same thing in any degree whatever. I believe, therefore, that the normal effect of exercise is slightly to increase temperature during the day, and to favour the early occurrence of the evening fall when the day's work is done. When the day's work continues till 6.30 or 7.0 the fall is postponed until the time of rest, when it quickly sets in.

While, therefore, I agree with M. Lortet in admiring the grand law set forth by the beautiful labours of Meyer, Joule, and Tyndall, and while I admit that "it is probably equally true both for living bodies and for machines constructed by the hand of man," yet I must say that its manifestation in the way claimed by M. Lortet would go far to destroy our present faith in that other property of moving equilibriums, namely, the power of self-regulation under unusual but not excessive strain, which is but one expression of the existence of a highly complex organism[1]. I ought, before concluding, to say a word upon diet, though all who know what Alpine walking is, are also aware how irregular diet must be. On walking days I take a little coffee and milk with bread and butter before starting, and breakfast on bread and meat with wine and water on the glacier two hours later, or thereabouts. I generally drink very largely of milk during the day and but little of water. Milk is often the staple of food until dinner in the evening. I never take spirits at all, and light wine only in very small quantities. I feel a strong desire for such hydrocarbons as oils, butter and honey, and eat them freely. These materials, no doubt, are most valuable in supporting the excessive combustion. That but little nitrogenous food should pass off as urea may be partially explained by the increase in size and hardness of all the muscles during training. This is probably due to exudation from the intramuscular capillaries under the pressure of contraction, and during the first few days I am generally aware of a tenderness and fulness in the muscles, due to congestion. I believe, accordingly, that no investigations into the excretion of nitrogen can be made with any valuable result, until training, with the rapid increase of muscular nutrition, has been fully established by a month's regular walking.

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[1] Mental activity, which deals with the construction of more complex molecules than physical, does not lower my own temperature, as very numerous experiments tell me.

OBSERVATIONS ON THE STRUCTURE OF THE HUMAN PLACENTA. By PROFESSOR TURNER. (Pl. v.)

THE Human Placenta from its great importance as the organ of union between the mother and the *fœtus in utero* has long been a favourite object of investigation, and many distinguished anatomists have from time to time directed their attention to the elucidation of its structure. But, notwithstanding all the time and labour which have been devoted to the subject, there still remained various points respecting which differences of opinion prevailed, and to determine the true meaning of which further observations were required. With the view of reaching a definite conclusion on these disputed questions, I have for some time past availed myself of many opportunities of investigating this organ, and have examined it not only after expulsion from the uterus in the ordinary course of labour, but whilst still connected to the wall of the gravid uterus.

I shall arrange my observations in the following sections:

1st. The relations of the maternal blood-vessels to the placenta.

2nd. The arrangement and structure of the decidua serotina.

3rd. The minute structure of the villi of the chorion.

1st. The relations of the maternal blood-vessels to the placenta[1].

No point in placental structure has been more the subject of discussion amongst anatomists than the arrangement of the maternal blood-vessels and their relations to the fœtal capillaries within the villi of the chorion. All indeed now agree that there is no direct flow of blood from the maternal into the fœtal vessels or *vice versâ*, and that mother and child each possess an independent circulation. It is also admitted that in the gravid uterus, when the placenta is fully formed, the

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[1] Many of the facts contained in this section were communicated to the Royal Society of Edinburgh, May 20th, 1872, and an Abstract of these is inserted in the *Proceedings* of that Society.

curling arteries do not communicate with the utero-placental veins through an intermediate plexus of capillaries.

By several obstetricians, viz. Robert Lee[1], Velpeau[2], Seiler[3], Ramsbotham[4], and Adams[5], it has been asserted that the maternal blood does not pass into the interior of the placenta, and this view has been revived by Braxton Hicks in a paper published in the May number of this *Journal*.

About the middle of the last century John Hunter[6], from the dissection of a gravid uterus, where the placenta was filled with wax injected through the curling arteries and uterine veins by Dr Mackenzie, and subsequently from injections made in conjunction with his brother William, concluded that he had established the circulation of the maternal blood through the placenta. This important conclusion has been supported and corroborated by the observations of many eminent investigators, more especially E. H. Weber[7], Owen[8], J. Reid[9], J. Goodsir[10], Van der Kolk[11], Virchow[12], Kölliker[13], Arthur Farre[14], and Ercolani[15]. But though there is a common understanding amongst these observers that the maternal blood enters the placenta by the curling arteries and flows through intercommunicating spaces—which have been variously termed the cells of the placenta, the cavernous spaces, the placental sinuses or lacunæ, the inter-villal spaces, or the placental bag or sac—prior to leaving the organ by the utero-placental veins, yet opinions are divided whether the blood is simply diffused through or extravasated into these spaces, without being confined in definite channels, or whether the spaces are limited by

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[1] *Philosophical Transactions*, 1832, p. 57.

[2] *Embryologie Humaine*, Paris, 1833.

[3] *Die Gebärmutter und das Ei des Menschen*, 1832.

[4] *London Medical Gazette*, 1834, and *Obstetric Medicine and Surgery.*

[5] *London Medical Gazette*, 1845, I. p. 758.

[6] *Animal Economy* and *Collected Works*, IV. p. 60.

[7] Quoted in *Müller's Physiology*, Baly's Translation.

[8] Notes to *Hunter's Works*, Palmer's Ed. IV. p. 69.

[9] *Ed. Med. and Surg. Journal*, Jan. 1841, and *Phys. and Path. researches*, p. 316.

[10] *Anat. and Path. Obs.* 1845, and *Anatomical Memoirs*, 1868, II. p. 415.

[11] Quoted by Priestley in *Lectures on the Gravid Uterus.*

[12] *Würzburg Sitzungsberichte*, 1853, and *Gesammelte Abhand.* 1856.

[13] *Entwickelungs-geschichte*, 1861.

[14] Uterus in *Todd's Cyclopædia.*

[15] *Mémoire sur les glandes utriculaires de l'uterus*, Bologna, 1868, and Algiers, 1869.

a membrane continuous with and belonging to the maternal vascular system, or derived from the decidua.

By the Hunters, Owen, Kölliker and Arthur Farre the uterine arteries and veins are suppcsed to open into the intra-placental spaces, through which the blood is transmitted so as to bathe directly the fœtal villi, without the intermediation of any maternal structure, and by Virchow it is considered that in at least the later stages of placental formation the villi grow through not merely the decidua, but the coats of the mother's blood-vessels, so as to hang free and naked in her blood. E. H. Weber, again, thought that the uterine vessels formed a network of wide canals within the placenta, the extremely thin parietes of which invested the fœtal villi. John Reid held that the intra-placental part of the maternal vascular system was dilated into a large sac, the lining membrane of which ensheathed the fœtal villi. Like Weber he believed that the maternal blood was retained within her own system of vessels. John Goodsir stated that not only did the maternal vessels form sinuses within the placenta—the vascular coat of which ensheathed the fœtal villi—but a layer of nucleated decidual cells was also prolonged over the villi, the latter of which were separated from the maternal blood by both these structures. Schroeder van der Kolk, again, described the interior of the placenta as subdivided by processes of the decidua into compartments lined by an epithelium derived from the decidua, which was also prolonged over the villi contained in these compartments so as to separate them from the maternal blood as it flowed through: and Ercolani also maintained that the uterine vessels did not subdivide within the placenta, but that the blood was enclosed in lacunæ or sinuses circumscribed by the decidua, the cells of which were prolonged on to and ensheathed the villi of the chorion.

My observations have been made on uninjected mature placentæ, and on injected specimens. The latter were as follows: *a.* normally separated placentæ into the substance of which a pipe was inserted, and a transparent gelatine injection coloured with carmine was gently passed: *b.* an attached placenta at about the 6th month of gestation, the pipe being inserted into a uterine vein in the broad ligament and a transparent coloured injection passed gently into the placenta: *c.* an attached specimen at the full time, the pipe being introduced into a uterine artery, and a transparent injection gently passed into the organ: *d.* an attached specimen at about the full time; a section was made through the placenta and uterine wall and a pipe was inserted into an opening on the cut face of the placenta, which was believed to be a divided sinus situated in a decidual dissepiment between two adjacent cotyledons, and the injection gently passed along it: in this preparation the fœtal vessels were also injected from the umbilical artery. In all the specimens the injection flowed with great ease into the placenta, which swelled up and became tense, as if it passed into a system of pre-existing freely inter-communicating spaces readily and naturally admitting of its diffusion, and not as if it were extravasated into spaces artificially produced by the gentle pressure to which the injection was subjected[1]. In specimen *b.* the coloured gelatine was traced along the sinuses situated in the muscular wall of the uterus into the so-called circular venous sinus and into the utero-placental sinuses in the decidua serotina. When the free edge of the placenta was raised, and the organ carefully separated from the uterus, the injected utero-placental sinuses, with distinct though delicate walls, were torn across, and the injection which they contained was seen to be continuous with that within the intra-placental spaces: at the margin of the placenta also a direct continuity was traced between the injection in the so-called circular sinus, and that within the placenta. The arrangement of these sinuses closely corresponded to the description written many years ago by Prof. Owen, of a specimen he examined. Veins of considerable size in the decidua vera, and extending for about an inch into the decidua reflexa, were also injected. In *c.* not only was the placenta injected from the uterine artery, but the coloured gelatine had penetrated into the venous sinuses, in the decidua serotina, and in the muscular wall of the uterus: large venous sinuses, lined by a distinct smooth membrane, were traced for $\frac{4}{10}$ths of an inch, into the placental substance along the inter-cotyledonary decidual dissepiments. In *d.* the injec-

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[1] In preparing these injections I have been aided by the skill of my Museum-Assistant, Mr A. B. Stirling.

tion was limited to those portions of the placenta adjacent to the spot where the pipe was inserted, but the neighbouring utero-placental sinuses and so-called circular sinus were also distended.

Portions of the different placentæ were hardened in spirit and thin slices were then made with Stirling's section cutter[1], and subjected to microscopic investigation. The transparency of the injection enabled me to study its relations to the villi and decidua with an accuracy such as it is not possible to attain with wax or other opaque injections. The drawing therefore (Plate v.) with which this paper is illustrated, is a picture of the villi and intra-placental maternal blood spaces as seen under the microscope, and not a mere diagrammatic conception of what the mode of arrangement might be considered to be, such as has generally been the case in the representations of the human placenta given by previous anatomists.

In these sections the villi may be seen to lie in the interval between the chorion and the decidua serotina. The trunks of many villi may be observed to arise from the chorion, though in other instances they are cut across transversely or obliquely. Deeper in the substance of the placenta also villi of large size are met with, divided either longitudinally, obliquely or transversely, some of which penetrate close to the decidual surface, and not unfrequently are attached to it. In all the larger villi, the umbilical vessels may be readily seen, even with low magnifying powers. Numerous secondary villi arise from these primary stems, which branch in the tree-like manner so often described. But by far the greater number of the smaller villi with their bud-like terminal offshoots have been cut off from their parent stems in the act of making the section. The villi are not so crowded together as to touch each other, but are separated by intermediate spaces filled with coloured gelatine. These spaces are circumscribed distally by the surface of the chorion from which the villi spring, proximally by the decidua serotina on the uterine aspect of the placenta, and laterally by the inter-cotyledonary or primary decidual dissepiments. The spaces within a given cotyledon freely communicate with each other, but the inter-cotyledonary

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[1] Described in this *Journal*, May, 1870.

dissepiments interfere with a ready communication between the injected spaces of adjacent cotyledons.

The injection was diffused with great regularity through each cotyledon, so as to surround not only the stems of the villi, but the multitudes of bud-like offshoots which branched off from them. Each villus was as it were immersed in a bath of coloured gelatine, which occupied, I believe, the place of the mother's blood, and gave one a vivid conception of the mode in which that fluid during life laves the villi of the chorion in which the fœtal capillaries are contained. The regularity of distribution of the injection is an important argument against its having been produced by extravasation, for if its presence in the placenta had been due to that cause, the gelatine would undoubtedly have been collected in masses in some localities and absent from others, and the villi would have been packed together and compressed. From the ease with which these intra-placental spaces are injected either through the artery or vein, or by passing the gelatine directly into the substance of the placenta, and from the uniformity and regularity of the pattern produced, few anatomists would be inclined to doubt that these spaces pre-exist in the placenta, that they freely communicate not only with each other, but with the curling arteries and utero-placental sinuses, and that during life they are distended with the mother's blood.

But this conclusion is supported by another important piece of evidence. For when thin sections through the injected placentæ—both in those still adherent to the uterus, as in those normally separated—were examined with the higher powers of the microscope, crowds of red blood-corpuscles were seen to occupy the intervillal spaces imbedded in the coloured gelatine. Scattered amidst these red corpuscles a proportion of white corpuscles was also readily recognised. Ocular demonstration was, therefore, afforded of the presence of blood in these spaces, and as there was no appearance of rupture of the fœtal vessels, although large numbers, not only of sections, but of teazed-out preparations, were examined, I have no reason to think that the blood could have been extravasated from them into the substance of the placenta. These corpuscles could, I believe, have been derived only from the maternal blood-vessels, with which the intervillal spaces were anatomically continuous.

I am unable, therefore, to agree with the opinion expressed by Dr Braxton Hicks, in the paper printed in the last number of this *Journal*, that the maternal blood does not exist in the intervillal spaces, and to the inference which he draws that there is no intra-placental maternal sinus system. For not only do I join issue with him on the question of fact, but I doubt if the specimens which he adduces in support of his views are of a kind to permit satisfactory conclusions on this matter to be drawn from them. I have experienced no difficulty in seeing blood-corpuscles in the intervillal spaces, both in attached and separated placentæ, in such numbers, and so generally diffused, that I cannot regard their presence, as he would infer, to be due to rupture of the vessels within the fœtal villi, or to imbibition of the blood at the decidual surface of the placenta after detachment of the placenta from the uterus.

Of the eight specimens which Dr Hicks adduces in support of his conclusions, the 5th, 6th, 7th, and 8th are admittedly diseased; the 5th being an aborted ovum "about 1 inch in diameter," the others being placentæ "in the state called fatty." The aborted ovum was in so early a stage that it is very questionable if the maternal blood-vessels had begun to exhibit the changes induced by gestation. He makes no mention even of blood-vessels within the fœtal villi, and until these are formed we have no reason to believe that the system of maternal sinuses is developed. The fatty placentæ were so diseased that the child in each case had died before delivery, and not only did he find no blood in the intervillal spaces, but, as he very candidly observes, the villi themselves were either altogether or almost entirely bloodless. The diseased state of the placenta, its bloodless condition, and the death of the fœtus, all prove that the placenta was no longer fulfilling its function as a great organ of circulation and nutrition, and it is not to be wondered at, therefore, that no blood was found in the intervillal spaces. But I would submit this is no evidence that they were not filled with blood when the organ was healthy and the child was alive. For it would be just as logical, or rather as illogical, to say that no blood circulated through the fœtal villi, because they were bloodless in these specimens; surely Dr Hicks is not prepared to support that inference! and yet the one conclusion would be quite as legitimate as the other! Further, in the 2nd specimen, about the 3rd month, the fœtal villi were also bloodless, a circumstance which indicates that here also a disturbance in the placental circulation had taken place. In his 3rd and 4th cases, about the 4th month of gestation, he admits that some blood was found in the intervillal spaces, and though his theory constrains him to suppose that its presence there was accidental, yet he confesses that he could not satisfactorily ascertain if it occurred from rupture of the villi, or came from the maternal side. His 1st case, an attached placenta in the 6th month, is the only example adduced of a well-grown healthy specimen in which he found no blood in the intervillal space; but as he gives no account how he determined its absence in this placenta, this solitary example cannot outweigh the mass of evidence on the other side of the question which has been advanced by the eminent anatomists referred to in the early part of this paper, and by the new observations which I have myself made.

Further, he alludes generally to differences in the amount of blood met with in the examination of placentæ when naturally expelled during labour. In regard to this I would merely say that when we reflect on the great pressure the detached placenta is subjected to by the uterine contractions which cause its expulsion; that this pressure is exerted on an organ, the uterine face of which possesses the numerous orifices of the torn-across utero-placental vessels, through which the blood can be squeezed, and that, moreover, the pressure can be assisted by the contraction of the muscular layer[1] of the caducous part of the decidua serotina, the wonder is not that no maternal blood, or only a small quantity, should be found in the intervillal spaces of a separated placenta, but that any of that fluid should be found there at all.

Lastly, I may state that no satisfactory explanation can be given of the passage of the blood from the curling arteries of

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[1] In the succeeding section I shall detail the reasons in support of the statement that a layer possessing the anatomical characters of smooth muscular fibre exists in the decidua serotina.

the uterus through the utero-placental sinuses into the sinuses within the muscular wall, unless an intra-placental circulation be accepted: for the continuity of the one set of vessels with the other in the fully formed human placenta, either directly or through the intermediation of a capillary plexus, although the latter has been assumed, has not only not been proved, but is opposed to recorded observations.

I shall now proceed to consider the theory supported by Weber, Reid and Goodsir, that the maternal blood-vessels are prolonged into the placenta, and that their lining membrane is reflected on to the chorionic villi, so as not only to ensheath and separate them from the mother's blood, but to form a limiting membrane for the spaces or passages through which the blood circulates.

I have been unable to satisfy myself of the accuracy of the special modification of this general theory, which has been advocated by E. H. Weber (*antea*, p. 122). There is indeed no difficulty in seeing the curling arteries pierce the decidua, or in tracing sinuses continuous with the utero-placental sinuses into the primary dissepiments of decidua which lie between the cotyledons, and in so far the mother's blood undoubtedly lies in definite canals, limited by the maternal vascular membrane. But I have as yet seen no evidence that the uterine vessels form a definite network within the cotyledons.

The view supported by Dr John Reid, that "the inner coat of the vascular system of the mother, or at least a membrane continuous with it," is prolonged over each individual tuft of villi, was obviously based, not on what he saw within the placenta itself, but on observations made as to the relations of certain villi situated at the uterine aspect of the placenta to the utero-placental veins, or the "sinuses placed next the inner surface of the uterus." For after pointing out how these villi protrude into the open mouths of certain of the sinuses only, and that "though they were so far loose and could be floated about, yet they were bound down firmly at various points by reflections of the inner coat of the venous system of the mother upon their outer surface;" he then goes on to say, "the outer surface of the placental vessels (villi?) has a smooth appearance, and they are, *we may suppose* (the italics are his own), everywhere enveloped in the inner coat of the vascular system of the mother, which, as we have seen above, is reflected upon them."

Dr Reid's observations, though detailed with great precision, and confirmed in many particulars by Professors Goodsir, Sharpey, Allen Thomson, Alison and Simpson[1], have been of late years so ignored by many writers, that I thought it advisable to re-investigate this part of the subject. In an attached placenta in the 9th month of gestation, where the fœtal capillaries had been injected from the umbilical artery with gelatine and carmine, I observed, on carefully drawing the placenta away from the inner face of the uterus, the dilated, cavernous, anastomosing arrangement of the utero-placental veins, with their valve-like semilunar edges, which has been so well described both by Owen and Goodsir. In various parts of the uterine surface of the placenta, but as it seemed to me especially near the outer edges of the cotyledons, where the primary decidual dissepiments dipped into the substance of the organ, tufts of villi could be distinctly seen projecting into the adjacent utero-placental sinuses. Their capillaries filled with a red injection, permitted me readily to distinguish them both from the coats of the maternal blood-vessels and from the decidua. These tufts occurred in the form of patches, oval, circular, or irregular in outline, and varied in diameter from about an inch to some fractional part thereof. When examined either with a pocket lens, or with higher powers of the microscope, the larger patches exhibited a somewhat cribriform aspect, owing to interlacing bars of membrane passing across them in an irregular manner. This membrane was continuous with and obviously formed a part of the coat of the utero-placental sinus, and was at times so thick that the injected villi were with difficulty seen through it, but at others so thin, smooth and delicate, as to represent only the inner coat of the sinus. It was in part merely in apposition with the villi, and could be readily raised from them, though in part it was attached by delicate processes, and seemed to bear out the expression used by Reid, of being reflected on to them. But in other portions of the patches no

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[1] See Note at conclusion of Reid's Memoir, as reprinted in his *Physiological and Pathological Researches.*

membrane could be seen, and the villi projected between the membranous bars free and naked into the canal of the sinus.

But the demonstration of this arrangement was by no means limited to the uterine surface of the placenta. For when the so-called circular sinus, lying along the outer edge of the marginal cotyledons, was carefully slit up, confirmatory views were obtained. This it is important to note, because whilst attached placentæ are difficult to get, and but seldom examined, the placentæ separated in the ordinary course of labour have the marginal utero-placental sinus not unfrequently so little injured that a ready demonstration of the relations of the villi to the maternal vessels can at any time almost be procured. I have sometimes seen the aperture in the wall of the marginal sinus so small that but a single tuft of branching villi projected through it, and the wall of the vein formed a distinct circular collar around the neck of the tuft. At other times I have seen a patch of villi upwards of an inch in length appear at the surface of the sinus lying next the cotyledon; the wall of the sinus presenting at the same spot the cribriform or reticulated aspect already described. Between these two extremes various intermediate forms have been recognised, and in this locality as on the uterine face of the placenta itself, though the thin wall of the sinus was sometimes reflected on to the villi, at others the tufts were freely moveable and projected into the canal of the sinus.

It is evident therefore from these observations that the decidua serotina does not form that complete and continuous membranous septum between the uterus and placenta which has been described by Robert Lee and many other obstetricians, but that its continuity is in various localities interrupted, so as to allow of the penetration of many of the placental villi into the utero-placental vessels. And I may further state, in confirmation of the above, that I have invariably found in examining placentæ separated during the ordinary course of labour, patches of villi, projecting through the decidua, especially near the margins of the cotyledons. These patches were surrounded by a sharply defined border of decidua, which from its precise form was apparently a normal arrangement, and had not been produced by a tear or violent detachment of the decidua from the surface of the exposed villi during the separation of the placenta. These exposed tufts obviously corresponded to those which I have described as projecting into the utero-placental sinuses on the uterine surface of the attached placenta.

My observations therefore are in part confirmatory of those of Reid; but though I have seen the wall of a sinus reflected on to some of the villous tufts, which project into its canal, yet I have not found that these villi are by any means all so ensheathed; still less am I prepared to say with him, that the tufts throughout the entire substance of the placenta are everywhere enveloped by the inner coat of the vascular system of the mother. My observations also are in part confirmatory of those of Virchow, as I have found numerous villous tufts unensheathed by any such membrane, but projecting free and naked into the canal of the sinus. The consideration, however, of the precise relations of the lining membrane of the maternal vascular system to the tufts within the placenta—if, in short, each tuft possesses an investing membrane, such as Goodsir named the external membrane of the villus—must be postponed until the minute structure of the villi is described in a subsequent section.

It is evident, in all those localities where the placental tufts project into the utero-placental system of sinuses, that the maternal blood is brought into such close relation with the fœtal system of capillaries, that important nutritive and respiratory interchanges can be effected between the two kinds of blood. The intimate relation, therefore, which can be so easily demonstrated in these localities, naturally leads one to infer that similar relations subsist throughout the entire substance of the placenta, and gives additional weight to the arguments advanced in an earlier part of this essay, in favour of the intra-placental circulation of the maternal blood.

Whilst reflecting on these relations, it occurred to me, that by a very simple experiment the direct continuity of the intervillal spaces with the canal of the sinuses, supposing such to exist, might be easily shown, and a demonstration afforded of the mode in which the mother's blood was returned from the interior of the placenta into her venous system. I accordingly in a separated placenta, where the marginal sinus was uninjured, introduced an injecting pipe into one of the cotyledons situated near the edge of the organ, and very gently propelled coloured gelatine into the intervillal spaces. The cotyledon swelled up and the injection flowed both into the marginal sinus at the edge of the placenta, and into the sinuses situated in the decidual dissepiments which divided the injected cotyledon from those adjacent to it. But as it might be objected that some natural barrier between these sinuses and the interior of the placenta had been broken down by the force employed in injecting, I modified the experiment in another specimen. In this I opened the marginal sinus before the injection was begun, and, as my assistant slowly and gently depressed the piston of the syringe, I carefully watched one of the cribriform surfaces on the inner wall of the sinus, where a large patch of villi was exposed, and saw the coloured fluid ooze quietly from between the villi out of the intervillal spaces of the cotyledon into the canal of the sinus, and observed that no structure was torn down before this oozing began. No doubt then remained in my mind, that a natural communication existed between the intervillal spaces in the interior of the placenta and the utero-placental sinus-system of veins.

These sinuses are so related to the placenta, as to communicate with the interior of the cotyledons either at the outer edge of the placenta, where the so-called circular sinus lies, or where the sinuses lie within the inter-cotyledonary decidual dissepiments, or where they come into contact with the uterine face of the placenta close to the plane of entrance of the primary decidual dissepiments into its substance. The communication is not as if the sinuses terminated abruptly by open mouths, as has usually been described; but rather by possessing cribriform apertures in their walls as they lie in contact with the placenta. From the relation of the sinuses to the margins of the cotyledons, whilst the curling arteries penetrate their uterine surface near their centre, the stream of maternal blood passes through each cotyledon from its centre to its circumference, and is effectually brought into contact with the whole of the fœtal villi.

The observations detailed in this section seem to me to put the question of the existence of an intra-placental circulation of maternal blood into the category of established and demonstrated facts, and to deprive it of that inferential or even theoretical character which it has hitherto held, and owing to which its accuracy has from time to time been assailed by various writers[1].

(*To be continued.*)

EXPLANATION OF PLATE V.

Vertical section through the entire thickness of a marginal cotyledon of the human placenta and the adjacent part of the uterine wall. Feebly magnified.

A. Marginal cotyledon.
B. Portion of an adjacent cotyledon.
C. Muscular wall of the uterus with its contained sinuses.

ch, Chorion containing the umbilical vessels. *ds*, decidua serotina containing the utero-placental sinuses. *pd*, primary or intercotyledonary decidual dissepiments. *sd*, secondary, or intra-cotyledonary decidual dissepiments. *sv*, stems of the villi arising from the chorion : multitudes of the smaller villi may be seen occupying the space between the chorion and decidua. At *a*, the primary decidual dissepiment is represented as reaching the chorion, and at *b*, the secondary dissepiments are connected with the secondary villi. *ms*, transverse section through the marginal sinus with villi projecting into it through the cribriform openings in its wall. *up*, utero-placental sinus with villi projecting into its canal. *up′*, sinus, anatomically continuous with the utero-placental system of sinuses, and situated in a primary decidual dissepiment.

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[1] When kindly revising the proof-sheets of these pages, Dr J. Matthews Duncan directed my attention to an experiment recorded by Dr Dalton (*Treatise on Human Physiology*, 1867, p. 615), who inflated the intervillal spaces in the attached placenta by blowing air into one of the vessels situated in the uterine wall. Dr Duncan told me that he had himself not unfrequently seen in the newly detached placenta, bubbles of air freely move in the intervillal spaces from the decidual to the chorionic surface.

ACTION OF DIGITALIS ON THE BLOOD-VESSELS.

By T. Lauder Brunton, M.D., D. Sc., and Adolph Bernhard Meyer, M.D.

Independently of each other, and in different ways, we both arrived at the conclusion that digitalin causes contraction of the small blood-vessels[1]. Wishing to support our views by still more conclusive proofs, we took advantage of the opportunities afforded to us in the physiological laboratory of the Berlin University to perform together, in February, 1868, some experiments on the subject. We are perfectly aware of their incompleteness, but circumstances having prevented us from continuing them, and the departure of one of us for a distant land rendering it improbable that we shall be able to resume them together, we now publish their results.

We believed that by a comparison of the form of the curves indicating the blood-pressure before and after the injection of digitalin into the circulation, we should be able to determine exactly whether it caused contraction of the arterioles or not. The kymographion we employed was that of Ludwig, as modified by Traube, and the experiments were conducted on dogs in the following manner. The animal being narcotized by hydrochlorate of morphia, a canula was inserted into the crural artery, and a curve (Fig. 1) showing the normal blood-pressure was described. Digitalin, suspended in a small quantity of distilled water, was then injected into the carotid artery, and pressure-curves again described. Injection into the artery was employed because Blake[2] found that digitalin produced a much greater effect on the blood-pressure when introduced into the circulation in this way than if injected into a vein. A comparison of the tracings thus obtained, after the injection, with that of the normal pressure and pulse (Fig. 1), showed a slowing of the pulse, accompanied by an increase in the mean

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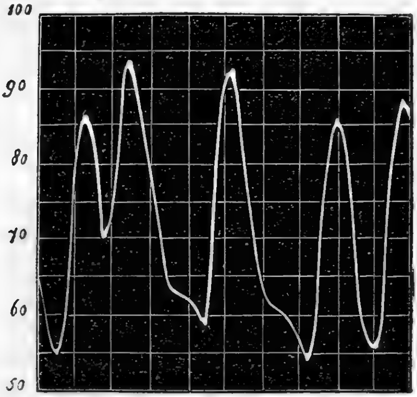
[1] T. Lauder Brunton *On Digitalis: with some Observations on the Urine*, London, 1868, p. 52, and A. Bernhard Meyer, *Zur Lehre von den Herzgiften in Untersuchungen aus dem physiologischen Laboratorium der Züricher Hochschule.* herausgegeben von Professor Fick. Wien, 1869, p. 71.

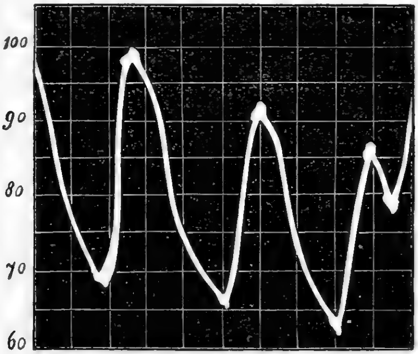
[2] *Ed. Med. Journ.* 1839.

FIG. I.



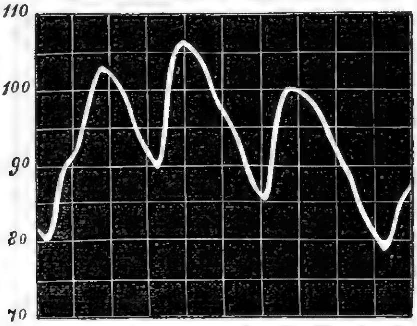
blood-pressure, while the height of the wave occasioned by each cardiac pulsation remained much the same (Fig. 2). The pressure continued gradually to rise although the pulse not only became slower and slower, but the oscillations of the mercurial column at each pulsation diminished in extent (Fig. 3). This rise could be due either to the heart propelling a greater quantity of blood into the aorta at each pulsation, or to the arteries, contracting so as to hinder it from escaping from the arterial into the venous system. The diminished height of the pulse-wave seems sufficient of itself to negative the former idea, and to show that the increased pressure can only be due to contraction of the arterioles, but

FIG. 2.



we think that a still clearer proof is afforded by the form of the wave. The time occupied in the ascent of the pressure-wave (indicated by the horizontal distance between the lowest and highest parts of the ascending limb) is nearly the same in Figs. 1 and 3, but the descending limb of the latter sinks very gradually indeed, while in the former it falls almost as quickly as it rises. What then is the explanation of this phenomenon? During the diastole of the heart, the sigmoid valves when healthy, as they were in this case, completely close the cardiac end of the aorta. The whole arterial system may then be compared to an elongated elastic vessel, from which fluid is issuing by a narrow opening. The greater the pressure of fluid in the vessel the more rapidly will it escape by the opening, the more quickly will the pressure consequently fall, and the more abrupt will be the descent of the pressure-curve. Now the mean blood-pressure in the normal tracing is somewhat over 70 millimetres[1], and the maximum height of the wave 44, while in that taken when the action of the digitalin was greatest, the mean pressure is somewhat over 90 mm., and the maximum 104. The fall of pressure ought, therefore, to be more abrupt, but instead of this it is more gradual. This alteration cannot, we think, be explained by any oscillations of the mercurial column independently of the blood-pressure, and can only be due to contraction of the arterioles retarding the flow of blood from the arterial into the venous system during the cardiac diastole.

FIG. 3.



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[1] The true heights are of course nearly double these, but for convenient comparison with the tracings we have taken the numbers as they stand in the figures.

In a recent paper, Boehm[1] considers that the rise in blood-pressure produced by digitalis, is chiefly due to the increased action of the heart, and that the condition of the arterioles has little or nothing to do with it. He seems, however, to interpret tracings of the blood-pressure in the arteries of mammals in the same way as those obtained from the excised heart of the frog, and apparently forgets that while in the latter the form of the diastolic as well as of the systolic curve depends on the heart alone, in the former the heart can have but little or no influence on the pressure in the arterial system during the diastole, since all communication between them is prevented by the closure of the sigmoid valves. The curves which he gives confirm our views, for they show the same gradual fall in the pulse-wave, after the injection of digitalis, that ours do, and being traced with Fick's spring-kymographion, are free from any fallacies due to oscillations of the mercurial column. The continued high pressure he observed during prolonged stoppage of the heart, and which he attributes to continuous cardiac systole, we would ascribe to contraction of the vessels so far as it is not due to changes in the respiration. If the arterioles were not contracted the pressure would fall, as *e.g.* in the experiments of Ludwig and Hafiz[2].

We next attempted to ascertain whether the slowing of the pulse is due to a direct specific influence of the drug on the roots of the vagus as supposed by one of us[3], or to the stimulation of these roots by the increased pressure of blood in the cranium produced by the contraction of the arterioles, as supposed by the other[4]. In order to do this we diminished the blood-pressure by the inhalation of nitrite of amyl after it had become high, and the pulse slow from the injection of digitalin. If the slowing of the pulse were due to a specific action of the digitalin on the vagus roots, it ought to continue although the pressure falls, but if due to stimulation of these roots by the high blood-pressure, it should disappear whenever the pressure is reduced. Our experiments showed that whenever the pressure fell after the inhalation of the nitrite of amyl the pulse became

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[1] *Pflüger's Archiv*, v. 190.
[2] Ludwig's *Arbeiten*, 1870.
[3] Brunton, *Op. cit.*
[4] Meyer, *Op. cit.*

quick. It might thus appear that the slowing is due in part at least to the high pressure, and not altogether to a direct influence of the digitalin on the vagus; but this must be decided by farther experiment.

Lastly, we tried to discover whether digitalis causes contraction of the vessels by acting directly on their walls or on the vasomotor centre. This we sought to do by observing whether the injection of digitalin into the circulation caused any alteration in the calibre of the vessels of the rabbit's ear after the sympathetic nerve of the same side as well as both vagi had been divided in the neck. The vagi were divided in order to prevent the digitalin from slowing the heart, and thus disturbing the circulation, and the sympathetic to prevent any influence being transmitted to the vessels of the ear from the vasomotor centre. The results of these experiments were not constant, and we are unable to draw any definite conclusions from them; but the fact that the vessels of the ears were occasionally seen to empty themselves more quickly after the injection of digitalin than before, seems to us to indicate an action upon the walls of the vessels themselves.

The conclusions to which we have arrived are shortly, 1st, that digitalin causes contraction of the arterioles. This is proved by the small height of the pulse-wave, and by its descent becoming more gradual after the injection notwithstanding the increased blood-pressure. 2nd, that the slowing of the pulse is probably due in part to the increased blood-pressure which results from the contraction of the arterioles. We gladly take this opportunity of expressing our obligations to Professor Rosenthal for the assistance and advice which he so constantly and kindly afforded us, and to Herr Merck of Darmstadt, to whose kindness we owe the digitalin we employed.

ON THE KOMBÉ ARROW-POISON (STROPHANTHUS HISPIDUS, D. C.) OF AFRICA. By Dr Thomas R. Fraser.

[The author communicated the results of some experiments with this poison to the Royal Society of Edinburgh, on the 21st of February, 1870; and an abstract of this communication has been published in the *Proceedings* of the Society (Vol. VII. No. 81, 1869—70, p. 99). As the circulation of these proceedings is, however, in great part limited to the Fellows of the Society, the author has thought it proper to reprint the abstract of his communication in a *Journal* where it will have the advantage of a wider and more general circulation.

In the following paper the abstract referred to will be reproduced *verbatim*, but a number of interpolations, consisting chiefly of details of experiments, will be introduced, in order to supply various omissions, many of which were rendered necessary by the original form of publication.

These interpolations will be included within brackets, so that they may be distinguished from the original abstract. The author has made no experiments with this substance since that abstract was published; he, however, entertains the hope of continuing the investigation.]

In nearly every narrative of exploration in uncivilised tropical regions, accounts are given, often no doubt somewhat fanciful, of poisonous substances which are said to possess the most remarkable properties. Usually these poisons are of vegetable origin; and the great majority may be included in the two divisions of *ordeal* and of *arrow* poisons, according as they are applied to one or other of these purposes. Among the most remarkable of the *ordeal-poisons* are the *Tanghinia venifera* of Madagascar, the *Physostigma venenosum* of Old Calabar, and the Akazga poison of the Gaboon; and of the *arrow-poisons*, the famous Curara or Wourali of South America, and the *Antiaris toxicaria* of Java.

The examination of these substances has not only proved of great value to physiology, but practical medicine has likewise been benefited—one of them, at least, being now an important medicinal agent.

In bringing before the Society a few of the results of a recent examination of a new arrow-poison, the author has to express his gratitude to the President, who very kindly gave him the specimens with which the experiments have been made. These specimens, consisting of a number of ripe follicles, were sent to Dr Christison by Mr Walker, and were collected in the expedition of the late Bishop Mackenzie.

Several specimens of the poison have likewise been sent to Professor Sharpey by Dr Kirk, H.M. consul at Zanzibar. Dr Kirk states "that the plant is a woody climber, growing in the forest, both of the valley and hills, and found at various places between the coast and the centre of the continent, above the Victoria Falls of the Zambesi. The stem is several inches in diameter, and rough outside. The plant climbs up the highest trees, and hangs from one to the other like a bush-vine. The flowers are of a pale yellow, and last for but a short time during the months preceding the first rains of the season (October and November). The fruit is ripe in June, and collected by the natives, who separate the rough outer coat before drying it, preserving the more leathery inner covering and the seeds[1]."

Dr Livingstone gives some interesting information regarding the poison in his *Narrative of an Expedition to the Zambesi and its Tributaries.* He mentions that arrows poisoned with it are used for killing wild animals only; arrows destined for the more noble object of killing men being poisoned with the entrails of a small caterpillar. Dr Livingstone says that in hunting, the natives follow the game with great perseverance and cunning: "The arrow, making no noise, the herd is followed until the poison takes effect, and the wounded animal falls out; it is then patiently watched till it drops; a portion of meat round the wound is cut away, and all the rest eaten" (p. 465).

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[1] Extract from letter to Professor Sharpey, dated January 1, 1864.

Dr Livingstone also says that the poisoned arrows are made in two pieces. "An iron barb is firmly fastened to one end of a small wand of wood, ten inches or a foot long, the other end of which, fined down to a long point, is nicely fitted, though not otherwise secured, in the hollow of the reed which forms the arrow-shaft. The wood immediately below the iron head is smeared with the poison. When the arrow is shot into an animal, the reed either falls to the ground at once, or is very soon brushed off by the bushes; but the iron barb and poisoned upper part of the wood remain in the wound. If made in one piece, the arrow would often be torn out, head and all, by the long shaft catching in the underwood, and striking against trees" (p. 466)[1].

[It would appear that this arrow-poison is widely distributed over Africa, for it has been found not only at Kombé, on the west coast near the equator, and in the Manganja country, near the Zambesi at the south-east of Africa, but also in the Gaboon district[2], in Guinea[3], and in Senegambia[4]. In the Gaboon district it seems to be called Inée, Onaye, or Onage[5].]

The follicles examined by the author vary in *length* from about nine and three-fourths to about twelve and one-fourth inches, and in greatest *thickness* from about one inch to three-fourths of an inch, and they vary in *weight* from about 130 to 330 grains. They contain from 100 to 200 seeds, each of which weighs about half-a-grain, and has attached to it a beautiful comose appendix, placed on an extremely brittle stalk. For the identification of the plant the author is indebted to Professor Oliver of Kew, who writes, in a letter dated 10th Dec. 1869: "I reopen your note to say that I have just dissected a flower, and conclude to name the Kombé plant *Strophanthus hispidus,* D.C.[6]" This plant belongs to the natural order *Apocynaceæ.*

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[1] Specimens of these arrows, which had been presented to Professor Maclagan by Dr Kirk, were exhibited to the Society.

[2] Pélikan, *Archives Générales de Médecine,* Juillet, 1865, p. 115.

[3] Van Hasselt, *Archives Néerlandaises des Sciences,* T. VII. 2me. Liv. 1872, p. 161.

[4] Baillon, quoted by Polaillon and Carville, *Archives de Physiologie,* No. 5, 1872, p. 526.

[5] Baillon, *loc. cit.*

[6] [Since this letter was received, Professor Oliver has been led, by a further

When the seeds contained in these follicles are bruised and treated in a percolator with rectified spirit, a greenish-yellow tincture is obtained. By distilling off the greater part of the spirit, and drying the residue on a water-bath and in the exhausted receiver of an air-pump, an extract is procured which weighs about 25 per cent. of the seeds employed, has an intensely bitter taste, and contains about one-half of its weight of an inert fixed oil[1]. From this extract the author has succeeded in separating a very powerful active principle. [He proposes that this active principle should be named strophanthin.]

As, however, the greater number of the experiments have been made with the extract, the results of these experiments only will be described in the following brief account of the physiological action of the Kombé arrow-poison, it being understood that the action of the active principle is of the same character.

When a small dose (one-twentieth of a grain) of this extract is mixed with a few minims of water, and injected under the skin of a frog, no distinct symptom is seen until about half-an-hour, when the animal's movements become somewhat sluggish. Soon afterwards the respirations cease, some stiffness occurs in the thoracic extremities, reflex sensibility diminishes, some stiffness appears in the pelvic extremities, and in about two hours after the administration voluntary movements entirely cease, and strong galvanic irritation produces no effect, even when applied to exposed muscles and nerves. An examination of the heart shows that it is completely paralysed, the ventricle being pale and contracted, while the auricles are dark and distended.

[To illustrate more fully the general symptoms that appear in frogs, the following experiment may be described :—

22nd January, 1870. 1.28 P.M. One-tenth of a grain of extract of strophanthus, suspended in 3 min. of distilled water, was injected under the skin at the left flank of a frog, weighing 287 grains. A

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examination of the botanical characters of the Kombé-poison plant, to doubt its identity with *S. hispidus;* and, accordingly, he has described it in the Icones Plantarum, No. 4, 1870, under the name of *S. Kombé*.]

[1] [Microscopic examination shows that this extract contains a large number of acicular crystals; and when the fatty matters are removed from it by ether, a hygroscopic substance is obtained, which consists in great part of crystals.]

small quantity was lost, owing to the adhesion of the fatty matter to the syringe:—1.36. The frog is less active in moving and jumping about; but the limbs retain a normal position:—1.43. When irritated, it jumps feebly:—1.47. The thoracic extremities are weak, and the thorax often rests on table:—1.56. The frog is on the abdomen and thorax; when irritated, pretty energetic movements occur of the four extremities, but the frog does not jump, although it obviously intends to do so. The respiratory movements of the throat are shallow, and those of the flanks are very feeble and occur only rarely:—2.8. A good deal of frothy mucus has been exuded; there is no exaggeration of the reflex excitability:—2.12. Almost incessantly, fibrillary twitches are occurring in the muscles of the abdomen. Both throat and chest respirations have ceased:—2.25. When placed on the back the frog attempts to turn, but cannot do so. No cardiac impulse can be detected. The fibrillary twitches continue, and are best seen at the lumbar region and behind the eyeballs. When the skin is irritated, pretty energetic movements occur in the two pelvic extremities and in the abdominal walls, and only feeble movements in the thoracic extremities:—2.45. Irritation of the skin causes feeble reflex movements in the two pelvic extremities; but none in the thoracic, which are now stiffly extended at right angles to the body. The fibrillary twitches no longer occur spontaneously; when, however, the skin at the coccyx or upper part of the thigh is irritated, a series of fibrillary twitches follow at the lumbar and gluteal regions:—2.55. Galvanic stimulation of the muzzle excites feeble reflex movements in the pelvic extremities, but none elsewhere:—3.10. Weak galvanic stimulation excites no movement; a very strong galvanic current, however, still excites extremely feeble movements in the pelvic extremities. The four extremities are now stiff and extended:—3.12. The heart was exposed, and it was found to be motionless, with the ventricle contracted and white, and the auricles distended and dark. Even the most powerful galvanic current from a Daniel's cell and Du Bois Reymond's induction apparatus, applied directly to its surface, produced no movement whatever:—3.30. Galvanic stimulation of the exposed right sciatic nerve caused only some very feeble and sluggish movements of the right foot. Strong galvanic stimulation of the exposed muscles of the right thigh failed to produce any contraction:—3.50. Galvanic stimulation of the right sciatic nerve no longer produces any effect. When the muscles of various parts of the body are stimulated, no movement occurs. A certain degree of general stiffness is present, and the four limbs continue extended:—*23rd January*, 12.50 P.M. Strong general rigor. The ventricle of the heart is contracted and white; the auricles are distended with blood.]

It was obviously suggested by these phenomena that this substance acts as a cardiac poison; and, accordingly, some experiments were made in which the heart was exposed before the administration, of which the following is an example:—

One-tenth of a grain of extract was injected under the skin of a frog. Five minutes thereafter, it was observed that the ventricular systole was somewhat prolonged; in six minutes, the ventricular diastole was imperfect, so that only portions of the ventricle dilated to admit blood from the auricles; in six minutes and thirty seconds, the greater portion of the ventricle was continuously pale and contracted, each auricular systole propelling merely a small drop of blood into the ventricle, where it produced a dark, pouch-like projection, which at times disappeared, and at other times only changed its position during the imperfect systole of the ventricle; in seven minutes, the ventricle altogether ceased to contract, while the movements of the auricles continued at nearly the normal rate; and in eighteen minutes, the auricles in their turn became motionless, but, in place of being contracted and empty like the ventricle, they were distended and full of dark blood. Notwithstanding this absolute paralysis of the heart, respiratory movements occurred for twenty-five minutes after the ventricle had ceased to contract, and the frog jumped about actively for some time after this.

[In many other experiments, the heart was exposed before strophanthus was administered, but only the two following will be here described. In the first, the poison was administered by the stomach, and in the second, by the rectum.

15*th January*, 1870. A frog, weighing 310 grains, was secured in the usual way. 11.54 A.M. The heart was exposed by removing the sternum:—11.56. Heart's contractions, 13 per 30 sec.:—11.59. Heart's contractions, 13 per 30 sec.:—12. A narrow gum elastic tube was passed into the stomach:—12.3. 0.2 grain of extract of strophanthus, suspended in 8 min. of distilled water, was injected down the tube into the stomach. Almost immediately violent efforts to vomit occurred, and a portion of the fluid was ejected:—12.6. Heart's contraction, 15 per 30 sec.:—12.7. "Pouching" observed at the heart's apex:—12.9. Heart's contractions, 14 per 30 sec.:—12.10. Heart's contractions, 14 per 30 sec.:—12.13. Heart's contractions, 15 per 30 sec.:—12.18. Heart's contractions, 15 per 30 sec.:—12.25. Heart's contractions, 15 per 30 sec.:—12.32. Imperfect ventricular diastole; a portion only of the ventricle dilating during diastole, and an appearance of "pouching" being thereby produced:—12.33. No diastole of ventricle, but a movement of that cavity occurs at times, although systole is continuously maintained:—12.35. A number of ventricular contractions, with diastolic dilatations in proper rhythm during 20 seconds, and, then, only movements of the ventricle without diastole:—12.36. No movements of ventricle, systolic contraction being continuously maintained. The auricles contract regularly 13 times per 30 sec.:—12.50. Auricular contractions, 6 per 30 sec. No movement of ventricle:—12.55. Auricular contractions have ceased: the auricles are dark and distended, and slight movements may be occasionally excited in them by direct irritation; the ventricle is pale and contracted, and no movement occurs when the surface is irritated:—12.58. The frog was unfastened, and it jumped about with considerable activity:—1.30. The frog is jumping and moving about, but less actively, and a little stiffness is present in the thoracic extremities. The heart is perfectly motionless:—1.50. Ditto:—2.45. The frog no longer moves about, and it is lying on the abdomen and chest with the lower jaw resting on the table. Reflex movements can be readily excited, but they are sluggish. The limbs are somewhat stiff:—*16th January.* 3 P.M. General rigor. No contractions can be excited by stimulating the nerves or muscles.

20th January, 1870. 2.25 P.M. The heart of a frog, weighing 330 grains, was exposed in the usual way, the frog being secured on the back:—2.28. Heart's contractions, 12 per 30 sec., regular and rhythmical:—2.30. Heart's contractions, 12 per 30 sec.:—2.31. Heart's contractions, 12 per 30 sec.:—2.34.30. Injected 0.1 grain of extract of strophanthus, suspended in 2 min. of distilled water, into the rectum, by means of a gum elastic tube attached to the orifice of the hypodermic syringe; and, afterwards, injected 1 min. of distilled water. A little of the fluid escaped:—2.40. Heart's contractions, 12 per 30 sec.:—2.45. Heart's contractions, 12 per 30 sec.:—2.48. Heart's contractions, 12 per 30 sec.; imperfect, the diastole being only partial at the apex:—3.10. Heart's contractions, 12 per 30 sec. The respirations continue:—3.17. Heart's contractions irregular; there being 5 ventricular contractions per 30 sec., and 3 auricular contractions to each ventricular contraction. The ventricle remains contracted during two auricular beats:—3.20. Ventricular contractions, 7 per 30 sec.; and 2 auricular contractions occur for each ventricular contraction:—3.23. Ditto. The respirations continue, and the frog often struggles:—3.24. Ditto. The ventricular diastole is imperfect, the upper half of the ventricle remaining contracted continuously, while diastole occurs at the apex only:—3.26. 6 imperfect ventricular and 12 perfect auricular contractions per 30 sec. The upper two-thirds of the ventricle now remains continuously contracted (in systole), and only the lowest third dilates during diastole. The diastole of the ventricle consists, therefore, of a mere "pouching" of the lowest third; and it is very brief in duration, being almost immediately followed by contraction (systole) of that third, which continues during two auricular contractions:—3.29. 6 imperfect ventricular contractions per 30 sec.; the appearance of a small dark "pouch" at the apex, and the occasional and rare appearance of a small "pouch" at the left base constituting its diastole. Auricular contractions, 12 per 30 sec., regular. Respirations continue, and, occasionally, there are general struggling movements:—3.32. 4 imperfect ventricular contractions per 30 sec., limited to the formation of a minute dark "pouch" at the apex. Auricular contractions, 12 per 30 sec., regular:—3.34. Only at long intervals a feeble movement occurs in the ventricle; which is now altogether permanently contracted and pale. Auricular contractions, 10 per 30 sec.:—3.35. No movement of ventricle. Auricular contractions, 6 per 30 sec.; at times, there is a long pause:—

3.37. On two occasions since last note, one imperfect ventricular movement occurred, following the formation of a minute dark "pouch" at the apex. Auricular contractions, 9 per 30 sec.:—3.39. Auricular contractions, 8 per 30 sec. One imperfect ventricular contraction during every three auricular contractions; a pouch forming at the apex at the second of the three auricular systoles, and being emptied immediately after the third:—3.43. Auricular contractions, 7 per 30 sec. No movement of ventricle, which is contracted and pale:—3.45. Ditto. Occasional gasping respirations:—3.50. Auricular contractions, 6 per 30 sec., feeble and irregular:—3.51.30. Auricular contractions have ceased; the auricles are dilated and dark, and the ventricle is contracted and white. Occasionally gasping respirations occur:—3.54. Ditto. Irritation of the surface of the ventricle causes a slight, almost doubtful, movement; while irritation of the surface of the auricles causes a series of contractions limited to the auricles and continuing for one minute, when they ceased after some struggles on the part of the frog:—3.57. Irritation of the surface of the ventricle produces no effect; and of the surface of the auricles, a single contraction followed by complete rest:—4.7. Galvanic irritation, even when powerful, applied to various portions of the ventricle and auricles produces no movement of the heart, but it excites violent struggles:—4.9. The frog was set free. It assumed a nearly normal posture, excepting that the thoracic extremities were extended and somewhat stiff; and, although able to move about pretty actively, it cannot jump:—4.30. Irritation of the skin caused pretty active reflex movements of the four limbs, but afterwards, one pelvic extremity remained extended in a rather stiff condition:—21*st January*, 11 A.M. General rigor: muscles hard and pale; veins full of blood, arteries empty; ventricle pale with some red patches, auricles dark and dilated.

In the last two experiments the heart was affected much more gradually than when strophanthus is subcutaneously injected; and the changes that take place in its action were, therefore, exhibited in a very distinct manner.]

The experiments that have been performed with birds and mammals have likewise shown that this poison acts primarily on the heart.

[By way of illustration, a few particulars may be given of an experiment on a pigeon, and of one on a rabbit.

9th February, 1870. 4.5 P.M. One-tenth of a grain of extract of strophanthus was suspended in 4 min. of distilled water, and injected under the skin at the right side of a healthy pigeon, weighing ten ounces:—4.12. The pigeon vomited a large number of entire wheat grains:—4.13. Ditto:—4.15. Ditto. Some mucous substance is also vomited. There is decided feebleness of the limbs:—4.20. Frequently vomited since last note, and some liquid excrement is now passed:—4.22. The pigeon is lying on the abdomen, the wings being used to steady the body. The pupils are dilated:—4.23. Some spasms occurred, which have an opisthotonic character:—4.23.30. Respirations have ceased. The pigeon is dead:—4.24.30. The heart was exposed and found to be motionless:—4.28. Direct galvanic stimulation of a sciatic nerve caused active muscular contractions:—4.30. Galvanic stimulation, even when powerful, applied to the surface of the heart produced no movement. Galvanic stimulation, applied to the muscles of the limbs and body, produced active contractions. The pupils are still dilated:—5.5. The muscles of the body no longer contract under galvanic stimulation; and they have become somewhat hard.

5th February, 1870. In an active rabbit, weighing 4 lbs. 2 oz., it was found that at 4.45 P.M. the respirations occurred 42 times, and the cardiac impulse 49 times, per 10 sec.; while the pupils measured $\frac{15}{50} \times \frac{13}{50}$ of an inch:—4.50. Two-tenths of a grain of extract of strophanthus, suspended in 10 min. of distilled water, was injected under the skin at the left flank:—4.53. Respir. 43 per 10 sec. The animal is restless:—4.57. Card. imp. 41 per 10 sec. Right pupil, $\frac{15}{50} \times \frac{13}{50}$ of an inch:—4.58. Respir. 47 per 10 sec.:—4.58.30. Card. imp. 35 per 10 sec.:—4.59. Respir. 39 per 10 sec.:—4.59.30. Card. imp. 39 per 10 sec.:—5.1. Card. imp. 39 per 10 sec. Grinding movements of the teeth:—5.2. Respir. laboured, and a sharp sound (like a "smack") occurs with them:—5.3. Card. imp. 35 per 10 sec.; the impulse is greatly reduced in strength:—5.4. Respir. 9 per 10 sec. Right pupil, $\frac{15}{50} \times \frac{13}{50}$ of an inch:—5.5. Card. imp. 35 per 10 sec. The sounds continue to occur with the respiratory movements:—5.6. Respir. 10 per 10 sec. Right pupil, $\frac{14}{50} \times \frac{13}{50}$ of an inch:—5.7. Card. imp. cannot be counted accurately, but it seems to occur about 38 times per 10 sec.:—5.8. Respir. 13 per 10 sec., no longer accompanied with any sound:—5.10. Respir. 23 per 10 sec.:—5.11. Card. imp. 41 per 10 sec., again distinct:—5.14. Card. imp. 38 per 10 sec. The rabbit is in a somewhat crouching posture:—5.14. Respir. 23 per 10 sec., jerking in character:—5.16. Card. imp. 39 per 10 sec.:—5.18. Respir. 26 per 10 sec.:—5.18.30. Card. imp. 38 per 10 sec. The lips and mouth are frequently opened and shut. Usually the eyelids are nearly closed:—5.22. Respir. 24 per 10 sec., jerking. The rabbit is unsteady, and tends to fall over:—5.23.30. Card. imp. 40 per 10 sec.:—5.25. The rabbit is now sitting, and the head often falls slowly and is raised sharply, with nodding movements:—5.26. Respir. 13 per 10 sec., feeble and jerking:—5.26.30. Card. imp. 33 per 10 sec. Right pupil, $\frac{14}{50} \times \frac{13}{50}$ of an inch:—5.30. Respir. 8 per 10 sec. Frequent shaking movements of the head:—5.32. Card. imp. cannot be counted, because of the jerking respiratory movements, and of frequent tremors; but it seems to occur about 24 times per 10 sec.:—5.34. Respir. 14 per 10 sec. Incessant tremors, chiefly of the head:—5.38. The rabbit is lying flaccidly, with the lower jaw resting on the table. Tremors occur frequently; and occasionally somewhat spasmodic movements take place, during which the body is tossed about:—5.41. Respir. 7 per 10 sec. The rabbit lies quietly on the side:—5.42. Card. sounds (as heard by the stethoscope) are very feeble and irregular. Right pupil, $\frac{10}{50} \times \frac{8}{50}$ of an inch:—5.42.30. Occasionally a gasping respiration occurs. Right pupil, $\frac{18}{50} \times \frac{17}{50}$ of an inch:—5.43. No respiratory movements; conjunctiva and cornea are insensible. The rabbit is dead:—5.44. No card. imp. can be felt, nor sound heard with the stethoscope:—5.46. The right sciatic nerve was exposed: weak galvanic stimulation produced no effect when applied to it, or to the surfaces of the exposed muscles in the gluteal region; but very strong stimulation when applied to the nerve excited a faint twitch of the foot, and when applied to the exposed muscles, a slow and feeble contraction. These conditions were present also at 5.50:—5.48. Right pupil, $\frac{8}{50} \times \frac{7}{50}$ of an inch:—5.52. The heart was exposed, and found to be motionless; while stimulation, even when powerful, produced no effect upon it:—5.55. Galvanic stimulation of nerves and muscles no longer produces any effect. The intestinal peristalsis is observed to be very slight:—6.30. General rigor, not very strong, except in the pelvic extremities. Right pupil, $\frac{8}{50} \times \frac{7}{50}$ of an inch.

Experiments were also made with dogs and cats, and results similar to the above were obtained.]

An endeavour was made to ascertain by what mode of action these very peculiar cardiac effects are produced. With this object experiments were made, in which the cerebro-spinal axis was completely destroyed, in which the vagi nerves were divided, and in which the peripheral terminations of the vagi were paralysed by atropia, previously to the exhibition of the Kombé poison; but no important modifications were thereby caused, and it is therefore obvious that the action on the heart is not exerted through the cerebro-spinal nerves. In other experiments, after complete cardiac paralysis, the surface of the heart was irritated by galvanic and other stimulants, but no effect was thereby caused.

[It is, therefore, perfectly obvious that strophanthus exerts an action upon the heart, which is independent of any change that it may produce in the physiological condition of the cerebro-spinal nervous system and of its connections with this organ. It is also obvious that this substance *acts in a powerful and direct manner upon the cardiac muscular fibre;* greatly prolonging, in the first place, the contractions of those fibres, and, ultimately, rendering it continuous, and only to be overcome when relaxation occurs as a natural consequence of *post-mortem* decomposition. Whether the intra-cardiac nerves are likewise affected, and whether a modification of their physiological activity is concerned in the production of these remarkable effects, it is extremely difficult to determine, seeing that their condition cannot readily be discovered in presence of so powerful and direct an action upon the muscular fibres that are controlled by them. The experiments that have as yet been made tend to show that the final stoppage of the heart and the production of the virtually permanent state of ventricular systole are independent of any modification that may be effected in the physiological condition of the intra-cardiac nerves. An example of these experiments may be here given.

19*th February*, 1870. 3.5 P.M. In a frog, weighing 361 grains, the heart was exposed:—3.9. Heart's contractions, 10 per 30 sec.:—3.14. Heart's contractions, 12 per 30 sec.:—3.16. Heart's contractions, 12 per 30 sec.:—3.17. One-twentieth of a grain of extract of strophanthus, suspended in a very little distilled water, was injected under the skin at each thigh (0.1 gr. in all):—3.20. Heart's contractions, 13 per 30 sec.:—3.21. Heart's contractions, 13 per 30 sec.:—3.23. Heart's contractions, 12 per 30 sec.:—3.24. Heart's contractions, 13 per 30 sec.; the ventricular systole is rather prolonged:—3.26. The ventricle no longer dilates; it is in a state of continuous systole:—3.28. Auricular contractions, 8 per 30 sec.; irregular:—3.29. Auricular contractions, 6 per 30 sec.; regular, but the diastole is only momentary:—3.32. Auricular contractions have ceased. Respir. 7 per 30 sec.:—3.34. The heart was removed from the thorax, by cutting the vessels at the base with a pair of scissors, and it was placed on a porcelain slab moistened with serum:—3.36. Galvanic stimulation, applied to various parts of the removed heart, produced no movement. The lower two-thirds of the ventricle was cut off with a pair of sharp scissors, and stimulated with galvanism, but without any effect—this separated portion remaining hard and contracted.

The data that have been acquired are not, however, sufficient to permit the assertion that no action is exerted upon the intra-cardiac nerves. It is by no means improbable that these nerves are directly acted upon; and that a modification in their physiological condition aids in producing the irregularities in the rhythm and the intermissions in the contractions of the heart, which occur during the earlier stages of the poisoning, and before the functional activity of the cardiac muscle has been destroyed.]

Another very prominent action of this poison is that exerted on the voluntary muscles, by which their activity is gradually impaired, and finally completely destroyed, so that the muscles are quickly in a condition of true *rigor mortis.*

[The nature of this action has to a certain extent been described in the preceding experiments; it will, therefore, be sufficient to give a brief account of some of the experiments in which its mode of production was investigated.

It is shown by the following experiment that the effects on the striped muscles of the body do not result from the paralysis of the heart which strophanthus produces:—

12*th January*, 1870.

A.	*B.*
1.15. A frog, weighing 266 grains, was placed on its back, and secured. The heart was then exposed:—1.20. Heart's contractions, 12 per 30 sec.	
1.21.	The heart of a frog weighing 268 grains was exposed in the same way as in *A*.
1.23.	Heart's contractions, 12 per 30 sec.
1.25.	A ligature was drawn tightly round the base of the heart, so as completely to stop the circulation; pulsation continued, however, in the large vessels close to the heart.
1.31. One-tenth of a grain of extract of strophanthus was injected under the skin of the two thighs:—1.39. Ventricular contractions have ceased, and the ventricle is pale and contracted. Auricular contractions, 11 per 30 sec. and feeble:—1.45. Auricular contractions have ceased:—1.46. The frog was set free: it jumped about actively:—1.49. The thoracic extremities are a little stiff, though still mobile. The frog can no longer jump, but it pushes itself about by vigorous movements of the pelvic extremities.	
1.50.	The frog is set free, and jumps about actively.

2. The thoracic extremities are very stiff. Irritation produces pretty active reflex movements of the pelvic extremities. Twitches occur at the lower part of the abdominal wall. Respir. has ceased.

2.10. ... ... The frog continues to jump about actively.

2.25. Irritation of the skin produces no movement, unless it be powerful, when slow but strong reflex movements occur in the pelvic extremities, but only at a considerable interval after the application of the irritant.

2.30. .. .. The frog jumps only feebly when irritated. Active spontaneous movements, however, still occur.

2.34. The pelvic extremities are now somewhat stiff, and when the skin is irritated very sluggish and feeble reflex movements occur in them. The twitches of the muscles have ceased.

2.35. ... ... The frog jumps spontaneously.

2.37. Strong galvanic stimulation applied to any part of the skin produces no effect, except when it is applied to one of the feet, when feeble movements occur slowing, which are strictly localised to the parts through which the galvanic current is passed. Galvanic stimulation applied to the exposed left sciatic nerve produces feeble movements below the left knee, but no reflex contractions:—2.52. Strong galvanic stimulation applied to the exposed sciatic nerve produces no contraction; when applied to exposed muscles in the left thigh and calf no movement whatever occurs.

3. ... ... The frog cannot now jump, but it pushes itself about by vigorously moving the four extremities.

4.15. ... ... The frog has for some time been lying on the abdomen, thorax, and lower jaw. Irritation causes well-marked reflex movements.

13th January, 1 P.M. ... ... Irritation no longer excites reflex movements. Galvanic stimulation of an exposed sciatic nerve causes only feeble movements of the limb supplied by the nerve; but it causes active contractions in the muscles, when directly applied to their surface. The body and limbs are perfectly flaccid.

1.5. General rigor is present everywhere; and the muscles are hard and pale. The ventricle is pale and rigid:—*16th January*, 12.10 P.M. Ditto:—*17th January*, 1 P.M. Ditto:—*18th January*, 11 A.M. The muscles are now softer. The ventricle is less rigid, and at several places dark patches are seen.

That the action of strophanthus upon the striped muscles of the body is not the result of any influence conveyed to them by the spinal motor nerves is rendered apparent by the following experiment:—

28th January, 1870. 3.58 P.M. One-twentieth of a grain of sulphate of methyl-strychnium was dissolved in 4 min. of distilled water, and injected under the skin at the left flank of a frog, weighing 290 grains:—4.25. Galvanic stimulation of the skin does not produce any reflex movement:—4.35. Galvanic stimulation of the exposed left sciatic nerve does not produce any muscular contraction in the left pelvic extremity or elsewhere:—4.40. A ligature was passed below the left sciatic nerve, and tied tightly round the middle of the left thigh; the nerve, therefore, not being included within the ligature:—4.44. The frog was secured on the back, and the heart was exposed:—4.45. Cardiac contractions, 9 per 30 sec., regular and rhythmical:—4.47. One-tenth of a grain of extract of strophanthus, suspended in 3 min. of distilled water, was injected under the skin at the right flank:—5.44. Heart's contractions are irregular and non-rhythmical: the greater part of the ventricle being continuously contracted and white, and only a small dark pouch being formed during diastole, which is emptied after each alternate auricular contraction. Twitches occur in the muscles of the abdomen and upper part of right (non-ligatured) thigh:—5.52. The ventricle is now altogether motionless, and it is white and contracted. Occasionally some feeble movements occur in the auricles. The twitches of the muscles have ceased; and the thoracic extremities are stiff:—*29th January*, 3 P.M. The ventricle is contracted, its anterior surface is pale, but its posterior is dark; and the auricles are dark and not distinctly contracted. Galvanic stimulation, applied to the heart, produces no effect. The thoracic extremities are stiff and hard; the right (non-ligatural) pelvic extremity is stiff, and the muscles at the thigh are hard, while those below the knee are less so. Galvanic stimulation of the muscles of the right pelvic extremity, or elsewhere in the poisoned region, produces no effect; but galvanic stimulation of the muscles (through the skin) of the left (ligatured) pelvic extremity produces active contractions in that extremity:—30*th January*, 4 P.M. Ditto:—31*st January*, 4 P.M. Contractions can no longer be produced in the left (ligatured) pelvic extremity by galvanic stimulation.

That the action of strophanthus upon the striped muscles of the body is the result of direct contact with these muscles is rendered apparent by the following experiment:—

24*th January*, 1870. 1.55 P.M. In a frog, weighing 350 grains, a ligature was tied tightly round the structures of the right thigh excepting the trunk of the right sciatic nerve:—2.3. The frog was secured on the back, and the heart was exposed:—2.4. Heart's contractions, 13 per 10 sec., regular and rhythmical:—2.9. One-tenth of a grain of extract of strophanthus, suspended in 2 min. of distilled water, was injected under the skin at the left flank:—2.19. Ventricular contractions, 13 per 30 sec., and imperfect; the middle zone of the ventricle remaining always in systole, and only the base and apex dilating in diastole:—2.21. Imperfect diastole of ventricle, 7 per 30 sec.; different limited portions become at different times pouched to constitute the diastole, and at times a drop of blood is distinctly seen to be conveyed from one part to another of the ventricle:—2.24. Ventricular contractions have altogether ceased, and the ventricle is contracted and white. Auricular contractions, 11 per 30 sec. The respirations continue:—2.34. Auricular contractions have ceased. Respiratory movements continue:—2.36. The frog was set free; and it moved about pretty actively:—2.50. Spontaneous jumps occur, but they are rather stiff. Both pelvic extremities are moved actively; but the left (non-ligatured) more so than the right (ligatured), the ligature round the right thigh having caused that limb to become a little extended:—3. Voluntary movements are feeble. Twitches occur in the left thigh. Respiration is represented by infrequent gasping movements:—3.14. Nearly constant slight twitches in the left (non-ligatured) thigh. The tone of the left pelvic extremity is impaired, as it now usually remains partially extended:—3.25. Slight irritation, applied anywhere, causes a series of movements in the body and four extremities, but these movements are now more active in the right (ligatured) pelvic extremity than in the left:—4.44. Galvanic stimulation, applied to the muzzle, causes reflex movements in the right (ligatured) pelvic extremity, but nowhere else:—5. Ditto. Galvanic stimulation applied to the sciatic nerve of the left (non-ligatured) pelvic extremity causes movements of that extremity:—5.30. Galvanic stimulation of the sciatic nerve of the left (non-ligatured) pelvic extremity no longer causes any movement: but when applied to the sciatic nerve of the right (ligatured) pelvic extremity, above the ligature, it causes active movements of the right pelvic extremity; and when passed through the spinal cord it is followed by energetic movements of this extremity, and of no other part of the body. Galvanic stimulation, even when strong, of the muscles of the left pelvic extremity causes no contraction. It is found that a cut section of one of these muscles has an acid reaction. The muscles of the thoracic extremities are also non-contractile and acid in reaction:—6. Ditto. While the thoracic extremities are very rigid, and the left (non-ligatured) pelvic extremity slightly so, the right (ligatured) pelvic extremity is flaccid and its muscles are contractile and alkaline.]

Regarding the other physiological effects, it is sufficient briefly to mention that the sensory and motor spinal nerves, the abdominal and cervical sympathetics, and the muscular walls of the stomach, intestines, bladder, and uterus, are paralysed at an early stage, although not until the blood-heart had ceased to contract; while the lymph-hearts of the frog retain a normal rate, long after paralysis of the blood-heart[1].

From these results it is apparent, that the primary action of the Kombé arrow-poison is isolated in the heart, and that it may therefore be included in the class of the *cardiac poisons*,—a class of poisons whose action has been most accurately defined by the researches of Kolliker, Vulpian, Pélikan, Hammond and Weir Mitchell, Hilton Fagge and Stevenson, Holme, Dibkowsky, and others.

[The author believes that this preliminary investigation enables him to make the following statements:—1. Strophanthus acts primarily upon the heart, and produces, as the final result of this action, paralysis of that organ with permanence of the ventricular systole. 2. Pulmonary respiration continues in cold-blooded animals for several minutes after the heart is paralysed. 3. The striped muscles of the body are acted upon: twitches occur in them; their tonicity is exaggerated; and, finally, their functional activity is destroyed, the muscles being

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[1] The author is indebted to Professor Sharpey of London for an account of some unpublished experiments made with this poison in 1862. The results mentioned in the above abstract harmonise in the most satisfactory manner with those obtained by Professor Sharpey.

then hard, and, soon afterwards, acid in reaction. These changes are accomplished subsequently to the final effect on the heart. They are the result of a direct contact of the substance with the muscles themselves, and are independent of the action on the heart, as well as of any changes that occur in the physiological condition of the cerebro-spinal nervous system. 4. The reflex function of the spinal-cord is suspended soon after the heart is paralysed; but the motor conductivity of the spinal-cord and of the nerve-trunks continues after the striped muscles of the body are paralysed. 5. The lymph-hearts of the frog continue to contract for many minutes after the blood-heart has been paralysed.]

PECULIAR MALFORMATION OF THE LEG AND FOOT.

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The following notes of a curious malformation are the result of an examination made by Mr Stewart and myself of the leg and foot of a man aged about 45, who had died of pyæmia. The specimen is now in the museum of St Thomas's Hospital, and Mr Stewart has kindly made the drawing of it which accompanies this paper. The existence of the malformation had not been known during the man's stay in the hospital, so that the amount of movement or usefulness could not be accurately determined.

Left leg extremely short; the Tibia measuring only nine inches, and the foot only six and a half. The foot had only three toes, and was very narrow, and was fitted to the leg in such a manner that its dorsum lay against the outer side of the leg; and, in consequence of the Tibia being considerably twisted outwards, the sole looked forwards as well as outwards.

The fibula was absent, except in its lower end; and this portion was displaced upwards. The muscular irregularities were numerous, and due in great measure to the peculiar arrangement of the bones, although there were some peculiarities which seem to have been the result of excesses of development.

Bones.—*Femur.*—Lower extremity small, and the margins of the two condyles more parallel than usual. The anterior surface flat and expanded below; so that the articular surface was broader than normal in front, while it was narrower than usual behind. The inter-condyloid notch not more than half its ordinary breadth, and peculiar in being encroached upon by articular cartilage continuous principally with that on the outer condyle. No groove for the popliteus on the outer condyle. Ligaments normal with the exception of the crucial, of which only a trace of the posterior could be found, while the anterior was deficient.

Tibia.—Much bowed, with the convexity forwards and inwards, and twisted outwards below, so that the fibula lay directly behind it at the ankle-joint. The relation of the upper end of the tibia to the knee-joint was peculiar; for the cavity of the joint dipped down deeply on the outer side, so that more than half an inch of the outer surface of the head of the tibia entered into the formation of the joint, being overlaid at this part by a much-thickened external lateral ligament: the ligament was so dense at this point, in fact, as to represent the head of the fibula which was wanting.

Fibula.—Entirely deficient in its upper seven-eighths. The lower end was present for about an inch and a half, representing the external malleolus, but placed an inch above the lower edge of the Tibia.

Foot.—The tarsal bones fused into one flat expanded irregular mass. The metatarsals were only three; and the phalangeals arranged as belonging to three toes, two of which were fused together at their bases. The metatarsus was articulated to the end of the tarsus, and projected both outwards and upwards, so as to form a concavity on the dorsum and at the side, making an angle of about 135° in each direction. The whole tarsus was solid, but evidences still remained here and there of original separation between the bones. Posteriorly the os calcis and astragalus were fused together, and the two lay nearly upon the same level, the astragalus being nearly altogether upon the inner side of the os calcis. The bone on the outer side of the tarsus continued forward, and evidence of a cuboid could be traced in a well-marked ridge on the plantar surface; the extremity of the bone articulated with the outermost and part of the next metatarsal bone. In the middle of the tarsal mass was a large hole which represented the normal interosseous groove; its existence as a foramen was explained by the lateral displacement of the astragalus; it was continuous anteriorly with a cleft between the representatives of the cuboid and external cuneiform. On the inner side the distinction between original bones was not so readily traced as on the outer side, for the parts were more completely fused together, and the prominences did not correspond so visibly with those in the normal foot; moreover, it appeared as if considerable modification of shape had possibly occurred as the result of the malposition of the tibia and fibula, or as a concomitant of it. There was, however, some indication of the existence of all the bones of this region, but the middle cuneiform appeared most deficient, while that portion which represented the external was much shortened. The upper surface of the astragalus-region of the bone was hollowed out into a cup which received the lower end of the Tibia, and in such a manner that the dorsum of the foot was thrown almost against the outer surface of the leg. There was a well-marked tuberosity on the portion which represented the heel.

The metatarsus consisted of three bones which from their character and from their relation to the tarsus seemed to be representatives of the first, third and fifth.

The phalanges which were continuous with the innermost of these three metatarsal bones were evidently those of a great toe. Those continuous with the outer two were peculiar. The proximal phalanges were united at their bases so that the outer two metatarsal bones articulated with a solid bifid phalanx, upon each horn of which was a second phalanx, which was again surmounted by an ungual phalanx.

Interosseous Membrane.—This was well marked and its outer margin took the place of the absent portion of fibula. The fibres ran obliquely downwards and outwards, except along the outer edge, where they passed downwards from the head of the tibia to the remaining piece of fibula as a connecting cord, not, however, forming a well-marked structure. The membrane was perforated above by a foramen through which the anterior tibial vessels and nerve passed.

FRONT OF THE LEG.—*Tibialis anticus:* origin and insertion as usual; an accessory slip, sent off from it in the lower part of the leg, became connected with the fibrous tissues above and behind the proper insertion into the internal cuneiform.—*Extensor proprius pollicis* arose from the representative of the head of the fibula and the upper three fourths of the interosseous membrane. In position and appearance it resembled the normal *extensor longus digitorum.* It was inserted as usual into the great toe.—*Extensor longus digitorum* arose below the *ext. prop. poll.* from the lower fourth of the interosseous membrane, and occupied therefore nearly the position of a normal *peroneus tertius:* it was, however, inserted into the dorsum of the representative of the outer toes in the ordinary manner.—*Accessory muscle:* a large unusual muscle was deeply placed between the *Tib. anticus* and the *extensors.* It arose with the former, but distinct from it, on the inner side of the anterior tibial vessels and nerves, and was inserted deeply on the dorsum of the foot all round the central hole between the representatives of the os calcis and astragalus.—*Peroneus longus* and *brevis* as usual.—*Peroneus tertius* absent.—*Anterior tibial vessels* and *nerve* only differed from the normal in their relations, by having to their inner side the large accessory muscle just mentioned.

BACK OF THE LEG.—*Gastrocnemius*, besides arising from the femur as usual, was slightly connected with the Tibia on the inner side, and was inserted into the os calcis without receiving the tendon of the *soleus.* Its inner head was perforated by the posterior tibial vessels and nerves.—*Soleus* arose from the interosseous membrane occupying the position of the upper fourth of the fibula, but was connected with the tibia only by means of a muscular slip, which ran from the oblique line. It was muscular throughout, and was inserted into the inner side of the os calcis distinct from the *gastrocnemius.*—*Plantaris* absent.—*Popliteus* absent.—*Tibialis posticus* as usual.—*Flexor longus digitorum* arose from fascia over the Tibialis posticus, but was unconnected with bone at its origin. It passed obliquely across the *Tibialis posticus* to its outer side, where it joined with the *Flex. long. pollicis.*—*Flexor longus pollicis* was small, and arose from the remaining portion of the fibula and from the interosseous membrane above it to about the middle of the leg. It passed downwards and was joined by the tendon of the *flex. long. digitorum,* and was inserted into the great toe at the ungual phalanx.—*The posterior tibial vessels* and *nerves,* after passing through the inner head of the gastrocnemius, reached the deep part of the leg and passed to the outer side of the flexor longus pollicis before arriving at the back of the ankle.

SOLE OF THE FOOT.—*Abductor pollicis* was arranged as usual; but muscular slips passed from the *flexor brevis pollicis* into its tendon of insertion.—*Flexor brevis digitorum* absent.—*Abductor minimi digiti* had a very broad origin from the os calcis, and a smaller one from the base of the last metatarsal bone; the insertion was into each side of the first phalanx of the outermost toe. The muscle gave off a large tendinous slip which passed across the foot to the base of the first phalanx of the great toe and was slightly attached to the base of the bifid phalanx. This slip appeared to represent the absent *flexor brevis digitorum.*—*Accessorius* arose as usual.—*Flexor brevis pollicis* was very large; some muscular slips, however, passed from it to the insertion of the abductor. *Adductor pollicis* as usual.—*Transversus pedis* absent. *Flexor brevis minimi digiti* arose as usual, but was inserted into the base of the bifid phalanx.—*Interossei* absent.—*Lumbricales* absent.—*Plantar vessels and nerves* did not present any further deviation from their usual arrangement than that the internal plantar nerve supplied the contiguous sides of the great toe and next.

DORSUM OF FOOT.—*Extensor brevis digitorum* as usual, but inserted into the two outer toes.

CASE II. A second similar case has come under my notice since the above notes were written, and may with advantage be recorded here, forasmuch as the dissection of the previous case helps to clear up some of the obscurities in this.

The patient (Eliza Ann B.) is 14 years old. She is rather slow and dull; but the rest of the family appear not to be very intelligent. None of her relations are known to have had any kind of deformity: and I cannot discover that her mother traces the peculiarity to fright during pregnancy.

She is well developed in other respects, but she walks very lame owing to the deformity. The right limb is from 3 to 4 inches shorter than the left, owing to defective development and bowing of the tibia, together with a peculiar displacement and deficiency of the foot, closely resembling that described in the first case; and this shortening has naturally produced a compensating tilt of the pelvis and lateral curvature of the spine.

The measurements are as follows:

Length of right tibia along its axis (*a*, *b*, *c*) 11 inches.
,, ,, vertically (*a*, *c*) 10 ,,
,, Left tibia along its axis 12½ ,,
Length of foot on outside, right = 8¼ inches. Left 9½ inches.
,, inner ,, ,, 9¼ ,, ,, 10½ ,,

The two thigh-bones were of equal length. The tibia could be felt throughout its whole length, and was bowed outwards in its lower half, and defective on its outer side, so that the lower articular surface was placed at about an angle of 60° to the horizontal. The fibula could not be felt by manipulation, but there appeared to be a small mass of bone immediately under the outer condyle of the tibia which represented the head of the fibula. No evidence of shaft or lower end could be detected. If a similar arrangement to that in Case I. existed, the lower piece of fibula representing the base could not have been easily recognized. In consequence of the bowing of the tibia the leg was a good deal expanded and flattened above the ankle.

The foot was small, and presented only 3 toes, 3 metatarsal bones, and a fused mass of tarsal bones. It was placed almost horizontally, and appeared to be rather displaced backwards and outwards from the base of the tibia, so that the inner malleolus projected constantly below the tarsus, while the representative of the heel lay outside and above the lower end of the tibia. In walking, the girl rested upon the surface of the inner malleolus, and the inner side of the first or great toe. There was not, however, the great displacement outwards and upwards which appeared to have existed in the first case.

The tarsus consisted evidently of a fused mass of bones, the lines of distinction between which could not be made out, but the heel projected in a very similar manner to that found in the other case.

The metatarsus was composed of 3 distinct bones, the inner of which resembled in shape an ordinary so-called first metatarsal bone, but was smaller than the corresponding one on the left foot.

The phalanges were 3 to each of the 3 toes, and each toe was separate from its neighbour, so that they could act independently. The second toe was less developed than the others, but the first was evidently from its shape a fairly developed great toe.

Case III. Mr Le Gros Clark has informed me of a third case, which has been under his notice for some years. In this there is no evidence of the existence of a fibula, and, just as in the two foregoing cases, there is associated with this peculiarity the same deficiency in the number of toes; only three toes exist, one of which is evidently a great toe.

Mechanical appliances have been resorted to to counteract the tendency of the tibia to bow more and more outwards, and the treatment has been so far successful, that the boy, who is now about 9, was able to skate last winter.

These three cases are curiously similar. In each, a deficiency or absence of the fibula is accompanied by the absence of two toes: but I do not feel there is enough to allow one to determine which toes are absent, though in the dissected case (I.) the second and fourth appeared to be so.

The absence of the fibula is associated with a bowing outwards of the tibia; and this seems to point to one important function of the fibula—that of acting as a bony chord to the slight arc which the tibia forms. With the absence of the outer malleolus, too, the foot is everted, and to such an extent, in Case I. as to allow it to be almost flattened against the outer side of the leg. Cases II. and III. are important, also in their surgical bearing, for both have been treated successfully by mechanical appliances. Division of the tendo-achillis was performed in Case III. to obviate the tilting of the heel which existed.

⁎ During this session I have found another instance in which muscular and tendinous fibres were arranged vertically on the outer surface of the external pterygoid, and gave origin by their deep surface to some of the horizontal fibres of the muscle. See Vol. v. of this *Journal*, p. 281. It existed upon the right side; but I am unable to state whether the peculiarity was present on the left side. The spheno-maxillary fossa did not appear unusually large. I did not notice any other peculiarities in muscular development in the subject.—W. W. W.

EFFECT OF STIMULI ON THE SECRETION OF THE PAROTID GLAND.

By P. Butler Stoney, *late Resident Physician in St Bartholomew's Hospital.*

A healthy young woman having been admitted to St Bartholomew's Hospital for a parotid fistula of long standing, I took advantage of the opportunity to make some experiments on the effect of stimuli of different kinds on the secretion of the parotid gland. The fistula was occasioned by a cut across the cheek received in childhood. The orifice of the duct was about two inches in front of the right ear. It was sensitive, but not particularly tender, and a fine probe could be readily passed up for some distance. There was no communication whatever with the mouth, so that the whole of the saliva secreted was discharged by the fistula and ran down the cheek. The power of various stimuli to increase secretion was estimated by the rapidity with which a drop formed at the fistular opening before and after their application. The method of procedure was as follows :—The duct was emptied by passing a soft napkin gently but firmly along its course from the gland to the orifice which was then completely dried, and the time which elapsed before a drop formed sufficiently large to run down the cheek carefully noted. The duct was then emptied and the fistula wiped a second time, the stimulus applied, and the time required for the formation of a drop again observed. The effect of mastication alone was first tested by giving the patient a glass stopper to chew. The experiments numbered I. II. and III. were all made at one time with a short interval between. The time required for the formation of a drop was in—

	Expt. I.	II.	III.	IV.
Natural secretion without a stimulus	3′	3′15″	4′	
While chewing	1′15″	1′	50″	1′20″
After chewing	2′40″	5′	6′	5′

The effect of taste alone was tried by placing sugar or tartaric acid first on the tip and next on the base of the tongue.

	Expt. I.	II.	III.	IV.
A little sugar placed on the tip of the tongue	3′	5′	12′	
Sugar on the base of tongue	4′15″	5′	12′	4′
Tartaric acid on the tip	10″	20″	30″	1′10″
Tartaric acid on the base	10″	30″	60″	30″

The effect of mastication and taste together was observed by allowing the patient to chew a piece of meat.

	Expt. I.	II.	III.	IV.
No stimulus	2′15″	2′45″	5′	
While chewing	15″	30″	30″	15″

The effect of mental stimuli was first tested by desiring the patient to think of something nice. This had no effect on the secretion whatever, and food was then placed before her.

	Expt. I.	II.	III.	IV.
Food placed before patient	1′13″	4′	6′	12′

These experiments show (1) that mastication alone stimulates the flow of saliva from the parotid to a considerable extent. (2) That the effects of taste vary with the sapid substance, sugar having no effect, while tartaric acid acts most powerfully. (3) That sapid substances act equally when applied to the tip and base of the tongue. (4) That the effect of mastication and taste together is much greater than that of mastication alone. (5) That mental stimuli had a considerable effect in one experiment, but in others none at all. These results accord in some respects with those obtained by Schiff in his experiments on dogs, though differing from them in others. This physiologist observed that mastication alone had little or no stimulating action on the parotid secretion in dogs, and Dr Brunton informs me that he has found this to be the case also in rabbits, while in the experiments above described the action was very distinct. The effect of the application of sugar and tartaric acid to the tongue of dogs was the same as that observed by me. The slight effect of purely mental stimuli in this case is remarkable, as the parotid is stated by Kühne to be readily affected by them, but this may have been due in great measure to the character of the patient, who seemed to be dull and unimaginative. An experiment was also made for the purpose of determining the time required for the absorption of drugs and their excretion by the saliva. For this purpose iodide of potassium was administered, and the saliva constantly tested till it appeared. The time which elapsed between its administration by the mouth, and its appearance in the saliva from the parotid duct, was found in one experiment to be 29 minutes 30 seconds.

VALVES IN THE RENAL VEINS. By WALTER RIVINGTON, M.S. Lond., &c.; *Surgeon to the London Hospital, and Lecturer on Anatomy at the London Hospital Medical College.*

FOUR or five years ago I was asked by Mr Curling to examine the Valves at the orifices of the Spermatic Veins, and while doing so met with many instances of Valves in the Renal Veins. At the time when I found them I was not aware that they had been previously described by Dr Edward Crisp in an Essay sent to the College of Surgeons in competition for the Triennial Prize for 1861. As these Valves are ignored in the ordinary Anatomical text-books, perhaps I may add here the results at which I arrived.

Specimen I. Male. Right Spermatic Vein opened into Vena Cava; Double Valve situated in a fossa. Left Spermatic Vein opened into renal; double valve. Right Renal Vein. No Valves inside, but at the lower part of the opening into Vena Cava was a small semilunar fold. Left Renal Vein. No valves; semilunar fold, as in the right, at the opening into Vena Cava.

Specimen II. Male. Right Spermatic. Double Valve; one fold, not very distinct, at opening into Vena Cava. Left Spermatic. Two fine valves at the orifice. Right Renal. No valves. Left Renal. No valves.

Specimen III. Male. Right Renal. Two veins opening into Vena Cava. At the orifice of the upper and larger no valve: at the orifice of the lower and smaller a beautiful double valve. Right Spermatic. Opening near the lower renal, a double valve in a fossa. Left Renal. No valves. Semilunar fold at the orifice. Left Spermatic, double valve at orifice.

Specimen IV. Male. Right Spermatic opened into Vena Cava. At the orifice is a valve, like the Eustachian Valve in the Heart, a semilunar fold directing the blood upwards. Inside, near the orifice, were two folds constituting a double valve. Left Spermatic. A single fold at the opening into the Renal Vein on the side nearer to the Vena Cava narrowing the orifice into the Renal. Right Renal. Fold near the orifice. Left Renal. Fold at the junction of Renal with Vena Cava below, apparently, to prevent blood coming up the Vena Cava from flowing into the Renal.

Specimen V. Male. Right Spermatic opened into Renal, but being broken off the orifice could not be satisfactorily examined. Left Spermatic. Double Valve. Right Renal. Two large valves at orifice, one below and one above, the lower being the larger. Left Renal. Semilunar fold as already described.

Specimen VI. Male. Right Spermatic. Opened into Vena Cava. A Double Valve, the lower lip being much larger. Right Renal. Fold across the vein a few lines from the orifice. Left Spermatic opened with the lowest tributary of the Renal into left Renal, and the two had a double valve. Left Renal. No valves at the orifice—but usual triangular fold. A single valve in Renal vein near the Spermatic.

Specimen I. Female. Ovarian Veins. Right opened into Vena Cava—large valve single, and at the lower side close to the orifice. Left. Two branches opening into Renal vein without valves. Two valves in the Renal vein about the middle of its course, the smaller one behind the other, both on the posterior wall.

Specimen II. Female. Ovarian Veins. Right. Opening into Renal near junction with Vena Cava—a fold on the surface of the lining membrane, between the opening of the Ovarian Vein and the Vena Cava. Left. No valve. Fold across the Renal vein nearer to the Vena Cava. Renal Veins. Right. No Valve. Left. Small Valve.

Specimen III. Female. Ovarian Veins. Right. Opening into Vena Cava—large lateral Valve. Left. No Valve. Renal. Right. No Valve. Left. Small Valve near orifice. There was a fold in the Vena Cava about $\frac{1}{4}$ in. in length near the left Renal.

Specimen IV. Female. Right Ovarian, opening into Vena Cava; single Valve. Left Ovarian, opening into Renal; double Valve. Right Renal. Chief branch, no Valve. Smaller and lower branch, double Valve. Left Renal. Semilunar fold at orifice into Vena Cava. Suprarenal Vein. Small Valve $\frac{1}{8}$th of inch from orifice. At the junction of some of the Renal tributaries Valves existed. Valves also existed at the orifices of the lumbar veins.

From the examination of these and some other Specimens, I am led to believe that a more extended investigation would be likely to establish the following points:—1. The existence of valves at the orifices of both the right and left spermatic veins, with a few exceptions. 2. These valves are, as a general rule, double, being formed of two crescentic folds of lining membrane, which leave a slit-like aperture between them. 3. When no valves exist at the opening of the left spermatic into the left renal vein, valves are generally present in the renal vein within a quarter of an inch from the orifice of the spermatic. One of the specimens here described exhibits two large valves at the orifice of the right renal vein. In this case the right spermatic vein opened into the renal, but its termination was mutilated, and could not be satisfactorily examined.

In another specimen, not given above, the left spermatic divided into two parts, opening into the renal an inch from each other. The part which opened nearer to the Vena Cava was furnished with two valves—the other had none; but two large valves existed in the renal vein, a quarter of an inch from the opening of this second branch into the renal.

The Ovarian veins yield similar results; but the valves would appear to be more often single than in the male. I have found both single and double valves in the renal veins of the female.

EXPERIMENTS AS TO THE CAUSES OF THE PRESENCE OF BILE PIGMENT IN THE URINE. By J. WICKHAM LEGG, M.D.

I WISH to place on record the results of a few experiments made during the last fortnight.

Naunyn[1] states that the injection of the bile-acids into the circulation is not followed by the appearance of bile-pigment, but only of hæmoglobin, in the urine. But if bile, or hæmoglobin, or æther be injected into the small intestine, the bile-pigments can be discovered the next morning in the urine. I can support Naunyn's first statement by experiments of my own; but on these I do not at present propose to dwell. The second statement is not, however, confirmed by those which are now published.

In all the experiments, Naunyn's directions for the operation were closely followed; the rabbits were under the influence of chloroform during the operation.

Sept. 24, 1872. A rabbit weighing 3 lbs. 6 c.c. of a 12 per cent solution of Plattner's crystallized bile were injected into the small intestine about 4 P.M. Next morning, the urine was clear, dark coloured like jaundiced urine, but very careful and repeated examinations gave no trace of Gmelin's reaction with nitric acid.

Sept. 25. A rabbit weighing 3½ lbs. 5 c.c. of hæmoglobin, prepared by alternate freezing and thawing of calve's blood, were injected into the small intestine at 5 P.M. Next morning, urine was straw-coloured, turbid; shewing no trace of reaction with nitric acid[2].

Sept. 27. A rabbit. 1 c.c. of æther was injected into large intestine about 2 P.M. Next morning, the urine was yellow, turbid, and gave no trace of a reaction with nitric acid.

Oct. 4. The same rabbit as that used on Sept. 24. 1·5 c.c. of æther injected into the small intestine at noon. The morning following, urine turbid, straw-coloured, and giving no trace of a reaction with nitric acid.

I wish to express my best thanks to my friend and colleague, Dr Brunton, for his courtesy in placing at my disposal his pharmacological laboratory at St Bartholomew's Hospital, in which all the foregoing experiments were made.

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[1] Naunyn, *Arch. f. Anat. u. Phys.* 1868, p. 401.

[2] This experiment has been repeated, with the same result as in the text, by F. A. Wolff (*Zur Pathologie des Ikterus*, Diss. Königsberg, 1869. Quoted in Henle's *Bericht f.* 1869, p. 176).

REVIEWS AND NOTICES OF BOOKS.

Diagrams of the Nerves of the Human Body. By W. H. **Flower**, F.R.S. 2nd Edition. London, 1872.

Professor Flower has brought out a new edition of his very useful diagrams exhibiting the origin, divisions, connections and modes of distribution both to skin and muscles of the nerves of the human body. By reducing the size of the diagrams, compared with those in the first edition, he has put them into a more convenient and portable form, which will render them more acceptable both to students and practitioners.

Leçons sur la Physiologie et l'Anatomie Comparée de l'Homme et des Animaux. By H. **Milne Edwards**, Vol. x. Part i. Paris, 1872.

In this part of his great work on *Comparative Anatomy and Physiology*, Milne Edwards describes the tegumentary system in the various groups of animals. The Part is marked by the same clearness of style and fulness of reference to authorities which have characterised all its predecessors.

Untersuchungen zur vergleichenden Anatomie der Wirbelthiere, von **Dr Carl Gegenbaur**, drittes Heft. Das Kopfskelet der Selachier, als Grundlage zur Beurtheilung der Genese des Kopfskeletes der Wirbelthiere, Leipzig, 1872.

This is a continuation of the author's well-known researches in comparative anatomy; it is a very elaborate introduction to the study of the vertebrate skull, and is illustrated by twenty-two plates.

Observations in Myology. By **Professor Humphry**. 8vo. Macmillan and Co.

This is a collection of the papers on the Myology of the Cryptobranch, Lepidosiren, Dog-fish, Ceratodus, and Pseudopus Pallasii, with the nerves of Cryptobranch and Lepidosiren, and the disposition of the muscles in Vertebrate animals, which have been recently published in this *Journal*.

Roser's Manual of Surgical Anatomy, translated from the fourth German edition by **John C. Galton**, M.A.

This is a useful book. The descriptions are clear, and it is well translated.

Anatomische Studien, herausgegeben von **Dr C. Hasse**, Prosector in Würzburg. Zweites Heft, Leipzig, 1871, drittes Heft, 1872.

Both parts are occupied chiefly by articles on the organ of hearing in Fishes and Reptiles, by Drs Hasse, Clason, and Ketel. There is also an article on the development of the atlas and the axis, by Dr Hasse, and one on the development of the vertebral column in Birds, by W. Schwarck.

REPORT ON THE PROGRESS OF ANATOMY.
BY PROFESSOR TURNER[1].

OSSEOUS SYSTEM.—Albert Kölliker communicates further observations (*Verh. der Würzburg Phys. Med. Gesellsch.* July 19, 1872) on the OCCURRENCE AND DISTRIBUTION OF TYPICAL ABSORPTION SURFACES IN THE BONES. (See *Report*, May 1872.) His object in this memoir is to furnish more precise topographical information of the position of these surfaces; and he conducts his enquiry partly by a microscopic examination of the bones of calves, which he tests with some other animals, and with infants in the 1st year; and partly by a series of madder-feeding experiments in young pigs and dogs. He then gives a detailed description of his microscopic researches. With reference to the madder-feeding experiments, he has arrived at the following facts: 1st, the madder unites only with the newly deposited bone and tooth substance, and leaves the parts already formed quite unaltered: 2nd, the bone-substance which has once been coloured by madder appears to preserve its colour for a long time, and loses its red bone substance only in consequence of the absorption which takes place in the coloured localities.——V. Feltz relates (*Robin's Journal*, 1872, 417) an experimental research into the power of ABSORPTION possessed by the MEDULLARY TISSUE OF THE BONES.——Wenzel Gruber in *Bull. de l'Acad. Imp. de St. Petersb.* 1872, 473) records further observations on SUPERNUMERARY CARPAL BONES (*Reports*, IV. 150, V. 375, VI. 433); an ossiculum intermedium in the left hand between the scaphoid, magnum and trapezoid: an ossicle in the distal row representing the absent process of the third metacarpal.——Dr Gillette communicates (*Robin's Journ.* Sept. 1872) an essay on SESAMOID BONES IN MAN. He divides them into peri-articular and intra-tendinous. The peri-articular are true bones arising in pre-existing cartilage, and are developed on the flexor aspect of the joints. The intra-tendinous are special to certain tendons, principally those of the lower limb which are on the flexor aspect: not unfrequently they remain cartilaginous during life.——Th. Simon relates a new case (*Virchow's Archiv*, LV. 536) of ABNORMAL WIDTH of the PARIETAL FORAMINA. See *Report*, I. 152.——Paul Broca (*Bull. de la Soc. d'Anthropologie*, 1872) describes a DEFORMITY OF THE SKULL met with in the people of Toulouse and the vicinity, which he calls *la deformation Toulousaine.* It was originally carefully studied by M. Gosse, who shewed how it was produced by bandages applied to the head in infancy. Broca's observations are of value in showing the modifications which take place in the shape of

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[1] To assist in making this Report more complete Professor Turner will be glad to receive separate copies of original memoirs and other contributions to Anatomy.

the brain in these deformed skulls.——Karl Langer communicates (*Denk. der Akad. der Wiss. Wien*, XXXI. 1870) an elaborate memoir on the GROWTH OF THE SKELETON, with the view of ascertaining if the increased growth in giants is due merely to normal processes of growth extending beyond what is customary, or to special modifications of formation.——P. Bouland enquires into the normal CURVATURES OF THE SPINE in man and animals (*Robin's Journal*, 1872, 359). He states, contrary to the opinion generally entertained, that the human spine does possess at the time of birth an anterior convexity in the cervical region, an anterior dorsal concavity, and sometimes an anterior lumbar convexity.

MUSCULAR SYSTEM.—Alex. Macalister has compiled a descriptive CATALOGUE OF MUSCULAR ANOMALIES IN HUMAN ANATOMY (*Trans. Roy. Irish Acad.* XXV.), which will be of great service to all engaged in the study of this branch of anatomy. He has made a careful search through the extensive literature of the subject, has classified the variations which have been described, and has incorporated with them a number of examples which have come under his own observation.——Wenzel Gruber continues his RECORD OF MUSCULAR VARIATIONS (*Bull. de l'Acad. Imp. de St. Petersb.* 1872, pp. 437 to 505): a *m. tensor fasciæ suralis*, which arose from the right semi-tendinosus and was inserted into the fascia of the calf of the leg; it almost exactly corresponded with the specimen described by the Reporter in the last number of this *Journal* (*Report*, VI. 442): additional variations in the *m. palmaris longus* (*Report*, III. 197): a *m. biceps brachii* with a coracoid origin and with an origin from the humerus close to the insertion of the tendon of the pectoralis major, but with no glenoid origin: a *m. radialis internus brevis* with two heads of origin, one the larger from the border of the radius, between the anterior and lateral surfaces; the other from the aponeurosis of the fore-arm; in the same arm (the left) a *m. cubito carpeus* was present, and in both arms the *abd. digiti minimi* had a supernumerary head of origin from the fascia of the fore-arm: a case in which the palmaris longus was absent, but where the *flexor carpi radialis* was subdivided into two bellies, one inserted normally, the other into the anterior annular ligament: a case of *m. costo-coracoideus supernumerarius* situated below the pectoralis minor, which arose from the 5th and 8th ribs, and was inserted into the tip of the coracoid process.——Gruber also has described (*Reichert u. du Bois Reymond's Archiv*, XIII. 663) cases of *m. tibio-astragaleus anticus* extending from the tibia to be inserted into the neck of the astragalus: and on p. 669 enters into an elaborate account of the *m. ilio-costo-cervicalis*, and of a new bursa mucosa on the tubercle of the 1st rib, and some accidental bursæ on the back.——S. Pozzi notes (*Robin's Journal*, 1872, 269) as a frequent variation in the *m. peroneus brevis* the passage of a slip from its tendon of insertion forwards to be inserted into the posterior end of the 1st phalanx of the little toe.——S. Haughton continues (*P. R. S. Lond.* May 2, 1872) his researches into some elementary principles in ANIMAL MECHANICS; No. V. refers to the most perfect form of a *plane quadrilateral muscle* connecting two bones, and No. VI. enquires into the *theory of skew muscles*, and investigates the conditions necessary for maximum work.——An elaborate experimental research into LOCOMOTION IN MAN has been conducted by G. Carlet. (*Ann. des Sc. Nat.* 1872, 1). It has been carried on in the laboratory of M. Marey by the aid of his graphic method. After giving a brief historical sketch of the subject he describes the apparatus employed, and then proceeds to consider what takes place when a step is made, and the part played by the lower limbs in walking. The movements of oscillation, inclination, rotation and torsion of the trunk are then considered, and the movements of the upper limbs. The essay concludes with a brief statement of the principal conclusions arrived at, and of the theory of walking which he considers that he has established.——M. Schlagdenhauffen communicates (*Robin's Journal*, Sept. 1872) the 1st part of an essay on the MECHANISM OF THE MUSCLES and treats of the action of the extensors.——G. M. Humphry has republished (Cambridge and London, 1872), with additions, the OBSERVATIONS IN MYOLOGY which appeared in the 6th Vol. of this *Journal*. The volume contains a description of the myology of *Crypto-branchus*, of *Lepidosiren*, of the Dog-fish, of *Uromastix spinipes*, of *Ceratodus* and of *Pseudopus pallisii*, with an account of the nerves of *Crypto-branchus* and *Lepidosiren*, and an essay on the disposition of muscles in vertebrate animals.

NERVOUS SYSTEM.—With the object of facilitating and making more exact the method of determining the DEPTH OF THE GREY MATTER OF THE CEREBRAL CONVOLUTIONS, H. C. Major (*West Riding Lunatic Asylum Reports*, II. 1872) has invented an instrument which he calls a *Tephrylometer*. It is made on the principle of a cork-borer, or cheese-taster, and consists of a glass tube 5 inches long, graduated in fiftieths of an inch. The bore of the tube is uniform throughout, the largest size he has employed is $\frac{8}{50}$ths of an inch, the smallest, $\frac{5}{50}$ths. The wall of the tube is about equal to a goose-quill in thickness, but is made to taper off at one end so as to facilitate its passage into a convolution. In using the tube its tapering end is carefully inserted into the *middle* of the free surface of a gyrus, from which the pia mater has been removed; the middle of the gyrus is selected so as to escape the grey matter which clothes its lateral aspects. About half the length of the tube is passed into the brain, and the forefinger is then pressed closely upon the free end and the tube is withdrawn. The thickness of the grey matter may be read off on the graduated scale. His observations have as yet been made only on morbid brains in which he has found that the depth of the cortical layer in the frontal and parietal lobes, and the annectent gyri is not subject to much variation, though in the two former it is as a rule somewhat greater than in the latter; in the occipital gyri there is a marked decrease in thickness, whilst the temporo-sphenoidal convolutions have thicker grey matter than the occipital. In the orbital convolutions the grey matter is diminished in thickness, in the island of Reil it is deep; the convolutions of the inner aspect of the hemisphere correspond closely with the temporo-sphenoidal, whilst the cuneate and uncinate gyri invariably show a falling off.——H. C. Major also in the same *Reports*, p. 41, records an examination of the MINUTE STRUCTURE of the CORTICAL SUBSTANCE of the BRAIN in a case of chronic brain-wasting, and compares it with the appearances seen in a healthy brain.——In a second memoir on the HISTOLOGY AND PHYSIOLOGY OF THE NERVES (*Archives de Phys.* 1872, 427) Louis Ranvier describes the connective tissue of the nerves. He arranges it as follows: the ensheathing tissue forming layers, the peri-fascicular and the intra-fascicular. The surfaces of the layers of the ensheathing tissue are occupied by endothelial cells. The intra-fascicular tissue is extremely delicate, the fibres run longitudinally and the plate-like cells which it contains are situated partly on the surface of the nerve-fibres, partly on the vessels, and partly on the groups of small bundles of the connective tissue. He recognises both blood and lymph-vessels in the trunk of a nerve, but he has not yet determined any communication between the latter and the intra-fascicular connective tissue.——M. Lavdowsky records (*Reichert u. du Bois Reymond's Archiv*, 1872, 55) observations on the minute STRUCTURE AND MODE OF TERMINATION OF THE NERVES in the urinary bladder of the frog.

EAR.—Urban Pritchard communicates (*P. R. S. Lond.* May 30, 1872) an account of the STRUCTURE AND FUNCTIONS of the RODS of the COCHLEA in man and mammals and in *Quart. Journ. Mic. Sc.* Oct. 1872, a description of the methods of PREPARING THE COCHLEA FOR MICROSCOPIC INVESTIGATION. These papers are in amplification of his graduation thesis submitted to the medical faculty of the University of Edinburgh in 1871. He points out that the rods of Corti vary in length according to their position in the cochlea; at the base the outer are as nearly as possible equal to the inner, but proceeding upwards both rows increase in length with great regularity, although not in the same ratio, the outer increasing with much greater rapidity, so that near the apex they are twice the length of the inner. The rods vary in length from about $\frac{1}{500}$th to $\frac{1}{200}$th inch, and there are about 3 rods in the inner to 2 in the outer row. He believes that not only for each tone or semitone, but even for much more minute subdivisions of the same, a particular rod is caused to vibrate.——H. N. Moseley also in the same number of the *Micros. Journ.* 374, describes methods of preparing the ORGAN OF CORTI for microscopical investigation.

EYE.—R. J. Lee in a paper on the sense of sight in birds (*P. R. S. Lond.*, May 16, 1872) describes the CILIARY MUSCLE in three species of the order *Rapaces;* the Eagle Owl, the Egyptian Vulture, and the Buzzard; and in a supplementary notice the eye in *Rhea Americana*, *Phœnicopterus antiquorum* and *Aptenodytes Humboldtii.* H. N. Moseley gives (*Quart. Journ. Mic. Sc.* Oct. 1872) some instructions as to the mode of making microscopic preparations of the EYES OF INSECTS.——Robinski commences an Essay (*Reichert u.*

du Bois Reymond's Archiv, 1872, 178) on the anatomy, physiology, and pathology of the CRYSTALLINE LENS in man and mammals.

VASCULAR SYSTEM.—Wenzel Gruber communicates (*Virchow's Archiv*, LIV. 445) an elaborate memoir on the ARTERIA THYROIDEA IMA and on variations in the origin of the INTERNAL MAMMARY and THYREO-CERVICAL ARTERIES. He not only reviews the literature of the subject, but communicates a series of new observations.—Paul Berger investigates the INTERNAL STRUCTURE OF THE UMBILICAL VESSELS (*Archives de Phys.* 1872, 551), and confirms the observations of Hyrtl on the presence of semi-lunar folds, connected with the wall of the arteries. In the umbilical vein also semi-lunar folds can be demonstrated. They are analogous to those found in the arteries, but larger. Often however they are rudimentary. He does not, however, with Hyrtl regard these folds as valves, but conceives them to be formed by the entire thickness of the wall of the vessel.

TEETH.—C. S. Tomes supports (*Quart. Journ. Mic. Sc.* Oct. 1872) the view that NASMYTH'S MEMBRANE on the enamel of a tooth is the homologue of the thick coronal cement of the herbivora. He believes it to be continuous with the outermost layer of the cement, which accounts for its imperfect calcification.

KIDNEY.—J. Hyrtl contributes a beautifully illustrated memoir (*Denk. der Akad. der Wiss. Wien*, XXX. 1870) on the PELVIS OF THE KIDNEY IN MAN AND MAMMALS. The various modifications in form which this structure may exhibit are described and in most instances figured.——W. Dönitz describes (*Reichert und du Bois Reymond's Archiv*, 1872, 85) the STRUCTURE OF THE KIDNEY of the African Elephant.——C. J. Eberth gives an account (*Centralblatt*, 1872, 225) of a network of SMOOTH MUSCULAR FIBRES which he states that he has found on the surface of the HUMAN KIDNEY. These fibres are not in connection with the muscular coat of the blood-vessels. He has not found them in the stroma or in the capsule, but immediately beneath the latter. He has never seen this muscular layer in the kidney of the ox, sheep or pig.

COMPARATIVE ANATOMY.

MAMMALIA.—Rt. Hartmann contributes the first part of a memoir (*Reichert u. du Bois Reymond's Archiv*, 1872, 107) on the ANTHROPOID APES, in which he treats of the Chimpanzee, and figures and gives a description of some crania of this animal.——C. J. F. Major notes (*Ann. Nat. Hist.* Sept. 1872) the occurrence of some FOSSIL MONKEYS in Italy, and precedes his description by a review of fossil quadrumana in general.——Alex. Macalister gives a short notice (*Ann. Nat. Hist.* July, 1872) of the anatomy of CYNOCEPHALUS HAMADRYAS.——Alex. Macalister communicates (*P. R. S. Lond.* Jan. 11, 1872) an abstract of a memoir on the MYOLOGY OF THE CHEIROPTERA.

——From the study of the brains of some, and of casts of the cranial cavity of other specimens, Paul Gervais prepares an elaborate memoir (*Nouvelles Archives du Muséum*, 1870) on the forms of the BRAIN IN THE CARNIVORA.——J. Chatin communicates (*Ann. des Sc. Nat.* XV. 1872) observations on the MYOLOGY OF HYŒMOSCHUS, viz. on the muscles of the fore and hind limbs. His researches lead to the conclusion that this animal has many points of affinity with the pigs. ——A. Sanson, in a memoir on the HYBRID OF THE HARE AND THE RABBIT (*Ann. des Sc. Nat.* XV. 1872), gives an account of the crania, and concludes that of the two kinds of hybrids obtained by M. Gayot one is absolutely identical with the rabbit, the other approaches more to the hare, less however by the shape of its skull than by its external characters.——Alph. Milne Edwards communicates his observations on the PLACENTA IN THE TAMANDUA (*Ann. des Sc. Nat.* XV. 1872). The specimen was *T. tetradactyla*, from New Grenada. Placenta unilobed and circular occupied a considerable portion of the surface of the ovum, and was very arched in its form. He applies to it the name *placenta discoïdal envahissant.* The villi are not simple, but with very serrated vascular vegetations amongst them, and presenting a considerable thickness in the central portion, so as to give to this part of the organ a spongy appearance; the border is well-defined, and beyond it the chorion is smooth. There are appearances of a decidua, but the condition of the specimen does not permit him to speak positively on this point. He found no trace of the allantois, but owing to the hardened state of the specimen, from its prolonged immersion in spirit, he was unable to separate the various membranes, and to isolate the constituent parts of the umbilical cord.——G. Pouchet records (*Robin's Journal*, 1872, 539) observations on the composition of the VERTEBRAL COLUMN OF MYRMECOPHAGA JUBATA.——Paul Gervais, from the study, more especially of casts of the cranial cavity, draws up a memoir (*Nouvelles Archives du Muséum*, 1869) on the forms of the BRAIN IN THE MARSUPIALIA.—— Rich. Owen, in continuation of his researches on the Fossil Mammals of Australia, communicates (*P. R. S. Lond.* Dec. 7, 1871, April 18, 1872) a memoir on the genus PHASCOLOMYS.——Alex. Macalister communicates some additional observations (*Ann. Nat. Hist.* July, 1872) on the MYOLOGY OF SARCOPHILUS URSINUS, and in the August number of the same volume an account of the MYOLOGY OF PHASCOLARCTOS CINEREUS.——CETACEA.—Thos. Dwight describes (*Mem. Boston Soc. Nat. Hist.* XI. 1871) the external characters and the skeleton of a young *Balænoptera musculus*, 48 feet long, captured in Oct. 1870 off Gloucester, Massachusetts. The flipper was 5 ft. 4in. long, and the height of the dorsal fin along the anterior edge was 1 ft. 2 in. The baleen was of a very light straw colour anteriorly, whilst further back dark stripes appeared on it, until the hindmost blades were of a uniform dark slate colour. He compares the skeleton, which is preserved in the Boston Museum, with the descriptions of the skeletons of *B. musculus* given by previous writers, and points out the variations which he has observed; the most remarkable being the presence of 63 vertebræ instead of 62 or 61, which is the number usually seen.——

P. Fischer notes the cases (*Journ. de Zoologie*, 1872) where the *Sperm-Whale* has been stranded on the sea-coasts of France.——MM. Delfortie and Fischer make notes (*Actes de la Soc. Linn. de Bordeaux*, 1872) on some *Cetacean bones from Léognan.*——Wm. Turner records for the first time the occurrence of *Ziphius cavirostris* in the British Seas (*Trans. R. S. Edinb.* 1872). The specimen was captured off Hamna Voe, Shetland, in 1870. The skull is described and compared with that of Sowerby's whale, a specimen of which is in the Edinburgh Museum of Science and Art. Reasons are given for separating Sowerby's whale from the genus *Ziphius*, and Gervais' name of *Mesoplodon Sowerbyi* is adopted. The differences in the form of the naso-premaxillary region in the two animals are, in the opinion of the author, sufficient to base generic distinction on.——Paul Gervais communicates (*Nouvelles Archives du Muséum*, 1871) a memoir on the *Baleen Whales.* He gives an account of the specimens in the Museum at Paris; he then enters into the characters of the skull as displayed in an antero-posterior median section; the relations of the vomer and the great mesial cartilage of the beak; the arrangement of the palatine bones, the characters furnished by the sternum and the form of the tympanic bones; he then considers the cerebral forms proper to the baleen whales, and concludes with some remarks on their classification.——W. H. Flower gives an account (*Trans. Zool. Soc.* 1872) of the external characters and skeleton of *Risso's Dolphin*, which he associates with the genus *Grampus* as *Gr. griseus.*——W. H. Flower also (*Ann. Nat. Hist.* 1872, 440) notes the discovery of the bones of a sub-fossil whale in Cornwall, which he considers to be the same as a Swedish specimen, described by Lilljeborg as *Eschrichtius robustus.*——P. J. van Beneden describes (*Bull. de l'Acad. Roy. de Sc. de Belgique*, No. 7, p. 6, 1872) various specimens of FOSSIL WHALES from Antwerp, which he refers to the following genera: *Balæna primigenius, Probalæna du Buisii, Balænula balænopsis, Balænotus insignis, Megapteropsis robusta, Plesiocetus garopii, Cetotherium hupschii, brevifrons, dubium and burtinii, Burtinopsis similis*, and *Herpetocetus scaldiensis.*——Jas. Hector gives an account (*Ann. Nat. Hist.* 1872, 436) of the New Zealand Bottle-nose, *Lagenorhynchus clanculus.*——H. Burmeister states (*Ann. Nat. Hist.* July, 1872) that after perusing Gervais's criticism of the *Globio-cephalus Grayi*, described by him in *Anales del Museo Publico de Buenos Ayres*, tomo 1, he has come to the conclusion that this cetacean is not a *Globio-cephalus*, but a true *Pseudorca*, which he regards as differing both from *Ps. crassidens* and *meridionalis*, and to which he gives the name of *Ps. Grayi.*

BIRDS.—M. Marey publishes a second memoir on the FLIGHT OF BIRDS AND INSECTS (*Ann. des Sc. Nat.* xv. 1872). He compares these groups of animals in reference to their mode of flight; he attempts a synthetic reproduction of the phenomena of flight in the bird, and records a new series of experiments to ascertain the dynamical conditions under which flight is effected. With reference to the figure of 8, described by the wing during flight, he gives a different interpretation of the cause of its production, and of the nature of the movements by which it is produced, from that which has been advanced by J. B. Pettigrew (*Reports*, v. 385).——Jas. Murie gives an account (*Ibis*, July, 1872) of the genus COLIUS, its structure and systematic place, and figures many of its bones. He considers it to be an aberrant form, and to afford the strongest proof of the interlinking of type; and whilst it presents affinities to the sparrows, parrots, woodpeckers, hornbills, the hoazin, the rollers, touracoes, and finches, yet it cannot be said to belong to any one of these groups. He conceives it to be annectent between the Coccygomorphæ and Coraco-morphæ.——J. Murie also in *Trans. Zool. Soc.* Nov. 7, 1871, makes a further note (*Report* VI. 447) on the POWDER DOWNS of *Rhinochetus jubatus;* and in *Month. Mic. Journ.* April, 1872, he gives an account of the development of VEGETABLE ORGANISMS within the THORAX of LIVING BIRDS.

FISHES.—J. Oellacher makes a series of contributions (*Siebold u. Kölliker's Zeitsch.* 1872, 373) on the DEVELOPMENT OF THE OVA OF THE RIVER TROUT.——W. K. Parker made the STRUCTURE and DEVELOPMENT OF THE SKULL OF THE SALMON the subject of the Bakerian Lecture (*P. R. S. Lond.* May 30, 1872).

REPORT ON PHYSIOLOGY. By T. LAUDER BRUNTON, M.D., D. SC., *Joint-Lecturer on Materia Medica and Therapeutics, St Bartholomew's Hospital, and* DAVID FERRIER, M.A., M.D., *Professor of Forensic Medicine, King's College, London.*

Nervous System.

PHYSIOLOGY OF THE CORPORA QUADRIGEMINA.—Knoll (*Eckhard's Beiträge*, 1869, *Centralb.* 17, 1872) investigates some disputed points in the relation of the corpora quadrigemina to the movements of the iris. According to Flourens these structures are the centres of the reflex action of the optic nerve on the pupil. Budge confirms this, but also states that lesion of the inner half of the nates causes paralysis of the iris on the opposite side, while, on the other hand, Rienzi states that in such lesions he never observed paralysis of the iris, but only a transitory contraction. Knoll attributes some of these differences to the fact that, in all probability, in some cases the fibres of the optic tract, which spread themselves out on the nates, may have been injured. He makes experiments in rabbits, and finds, on cutting through the optic nerve between the eye and the commissure, there is complete dilatation and paralysis of the pupil on that side alone. If section is made between the commissure and the corpora quadrigemina complete paralysis ensues of the opposite iris, and of that alone, a fact which shows complete decussation of the fibres of the optic tracts in the chiasma. The action of the oculo-motor on the iris is purely reflex. Sections of the optic thalami and corpora quadrigemina cause no affection of the iris, so long as the fibres of the optic tract are avoided. If these are involved then paralysis of the opposite pupil results. Lesions of the corpora quadrigemina do not seem to affect the movements of the animal. Irritation of the nates causes dilatation of both pupils, especially that of the same side. This ceases to be the case if the cervical sympathetics are cut, which seems to show that the action is to be attributed to downward irritation of the oculo-spinal centre.

GALVANISATION OF THE BRAIN.—Hitzig (*Reichert u. du Bois Reymond's Archiv*, 1871, 716—770 and 771—772) describes peculiar phenomena caused by passing constant currents through the head; some of which had already been observed by Purkinje. Vertigo is produced, especially if the current is directed from one mastoid fossa to the other, or if one pole is placed in one fossa and the other on any other point. In addition to the vertiginous feeling there is an inclination of the head, or of the whole body, towards the anode when the current is formed, and towards the cathode when it is broken. Objects appear to sink towards the side of the cathode when the current is formed. Strong currents also cause involuntary movements of the eyes, similar to nystagmus. Besides these, other movements of the eyeballs, first to one side and then to the other, are observed, following each other with a certain amount of rhythm, beginning from the anode. When the currents are very strong both eyeballs are fixed in the angles towards the cathode, and oscillate there. Circular movements of the eyeballs are also seen. From various experiments Hitzig thinks that the movements are due to irritation of parts of the third and fourth nerves in the left eye when the current passes from left to right, and in the right eye to irritation of other parts of the third and the sixth when the current passes in the contrary direction. The intra-cerebral irritation appears due to the same causes as the electrotonic state of nerves. He thinks that some of the vertiginous phenomena are in reality due to the involuntary movements of the eyeballs, and the consequent apparent movement of external objects. The other movements, which result from opening and closing the current, occur, whether the eyes are open or shut, and are apparently voluntary in character, caused by the feeling as if the head were inclined towards the cathode, and the desire to restore the equilibrium of the body. If the eyes are opened the movements of the body itself cease, but are transferred to external objects.

Similar movements are observed in rabbits. Hitzig attributes the rotatory movements, which are observed in animals on lesions of the cerebellum, to voluntary efforts, directed with a desire to recover equilibrium.

CAUSE OF SLEEP.—Obersteiner (*Archiv f. Psychiatrie*, Bd. 29) considers the proximate cause of sleep to be the accumulation of acid products in the brain, just as in the case of muscular fatigue. The periodicity is merely a matter of custom like many other bodily functions. All conditions which interfere with the conveyance from the brain of acid combustion-products tend to induce sleep, and all conditions which favour their removal have a contrary effect. The conditions lie chiefly in the state of the circulation. Active hyperæmia in this way prevents sleep. Passive hyperæmia or venous congestion has an opposite effect. Anæmia, by diminishing the activity of interchange between the blood and tissue, favours sleep. Changes in the chemical constitution of the blood, such as by narcotics, interfere with the absorption and excretion of the acid products, and hence cause sleep. He compares the cerebral vessels to the bronchial vessels, and destined only to nourish the tissue. The real initiative to cerebral action proceeds from the nervous system itself. Hence to allow of rest from the ordinary association links of cerebral action the brain must be disconnected from outward stimuli. When this is done a tendency to sleep ensues. So also if one impression is kept up long. The continuance of an impression is equivalent to none at all. The will acts as a sort of inhibitory centre to the reflex cerebration. In sleep this is at rest, and hence cerebration shapes itself into dreams. These may be conditioned by stimuli which are not of sufficient intensity to rise into consciousness.

INJECTIONS INTO THE BRAIN SUBSTANCE.—Beaunis (*Gazette Med.* Nos. 30—31, 1872) thinks that the injection of corrosive and other fluids into the brain by means of a fine needle would be of great service in investigations into the physiology of the great nerve centres, inasmuch as the lesions so produced should be more localised than by the process of vivisection. The results have generally been fatal convulsions after movements of various kinds when injections were made into the corpora striata and cornu ammonis.——H. Nothnagel (*Centralblatt*, No. 45, 1872) also gives a method by which the functions of various parts of the brain may be studied. It consists in injecting a concentrated solution of chromic acid through a small hole in the skull, by means of a subcutaneous syringe. The part injected becomes green and hard, surrounded by partial encephalitis. The function of the part is completely destroyed, while the lesion is exactly circumscribed. Nothnagel has made over one hundred experiments, the animals living at least eight to fourteen days. He promises soon to publish his results.

CONDUCTION OF SENSORY IMPRESSIONS IN THE SPINAL CORD.—Nawrocki (*Ludwig's Arbeiten*, VI. 89) has continued and extended the research begun by Miescher under Ludwig's direction (see this *Journal*, Nov. 1871, p. 220). Miescher found that the sensory impressions, which produced an action on the blood-pressure, were chiefly conducted up the cord in the lateral white columns, but he did not determine whether they were not partly conducted along the grey matter as well. Nawrocki's experiments, however, show that the impressions are conducted entirely along the lateral columns, and not at all by the grey matter. They were conducted in the same way as Miescher's, with this improvement, that the two small knives, used to limit the extent to which the cord was divided, were united into one instrument instead of being used separately.

INSENSIBILITY OF THE SPINAL CORD.—Wolski (*Pflüger's Archiv*, V. 290—291) agrees with those who hold that the substance of the cord is itself insensible to irritation. In order to localise the irritant he used fine needles. No irritation was caused in frogs or dogs until the needle was inserted close to the roots of the nerves.

IRRITATION OF THE CUTANEOUS NERVES BY SULPHURIC ACID.—Baxt (*Ludwig's Arbeiten*, VI. 69) sought by experiments on frogs, after the removal of the brain, to determine the time required by various dilutions of sulphuric acid to produce reflex contractions. While doing this he noticed that the frog is less sensitive to the acid at first, so that the reflex contractions occur more and more quickly when the same acid is applied at regular intervals; until after several applications have been made they require the same time at each irritation. A weak acid, applied after a stronger one, will produce a contraction more quickly than it would have done without the previous application of the stronger one. His experiments were made with very dilute acids from 0.0003 to 0.003. The former never produced a contraction at all, the latter did so in about a second.

The sensibility varied in different frogs. No direct proportion exists between the strength of the acid and the time it requires, but if acids of different strengths are successively used a proportion is found between the differences of strength and the differences in time, for while the former diminish in an arithmetical, the latter do so in a geometrical ratio. The irritation must then be due not only to the amount of acid which reaches the nerves but to the rapidity with which it does so. From this it appears that it is not the condition of the nerve which exists after the acid has reached it, but only the process of alteration in it that causes irritation.

TROPHIC ACTION OF NERVOUS CENTRES ON MUSCULAR TISSUE; ALTERATIONS IN MUSCLES AFTER LESIONS OF NERVES.—Vulpian (*Compt. rendus*, LXXIV. p. 964) finds that the grey matter of the spinal cord and medulla, and the corresponding parts in the Pons Varolii, exert a trophic influence upon muscles through their motor nerves as well as upon the motor nerves themselves. When the motor nerves are cut, the muscles, which are thus severed from connection with their trophic centres, become atrophied, and their contractility diminished. That the trophic influence is conveyed to the muscles through the motor nerves, and not through sympathetic fibres, is shown by the facial muscles becoming atrophied after division of the facial nerve close to its origin, when it contains only motor and no sympathetic fibres, as well as by the atrophy of muscles, which occurs after degeneration of the anterior horns of the grey substance in the spinal cord.

MOVEMENTS IN NERVE FIBRES FROM ELECTRIC IRRITATION.—Engelmann (*Pflüger's Archiv*, v. 31) on irritating either the sciatic nerve of the frog, the nerves of the web or the small ones on the inner side of the leg by single induction shocks, noticed that the white substance of Schwann in some of the fibres became thicker, and its outlines jagged. Similar appearances were also produced in dead nerves and in pieces of white matter separated by ligatures from the centre parts of the nervous system. These changes he attributes to the rise in temperature caused by the current passage of them, as similar ones could be produced by warming the nerves to 33—35° C. He believes that in ordinary experiments on the irritation of nerves these changes may play a considerable part.

AN EFFECT OF GALVANIC CURRENTS ON MUSCLE AND NERVE.—Hermann (*Pflüger's Archiv*, v. 223—275) finds that the conduction in living muscle is better in the longitudinal direction than in the transverse, but if the muscle is brought into the state of rigor by heat, there is no difference in the amount of resistance offered to the current. The same is true of the nerves. Hermann explains these facts by internal polarisation in the region between the sheath and its contents. The resistance manifests itself soon after the closure of the current, and is the same in interrupted constant currents as in continuous. With changes in the direction of current, however, the resistance in the transverse direction is less than when the current is constant, though it is still greater than the longitudinal resistance. In nerve, little difference is observed. In order to account for these phenomena by polarisation, it must be supposed that in muscle and nerve, contrary to other electrolytes, the signs soon become reversed with frequent reversal of the current. Investigation of the polarisation after opening of the current supported this idea. When the polarised currents of a transverse and longitudinal preparation of muscle were examined after opening the current it was found that the polarisation current of the transverse was greater than that of the longitudinal. It is otherwise in nerve. The longitudinal polarisation current exceeds the transverse, so that the longitudinal polarisation of the dead nerve is greater than the transverse polarisation current of the living nerve. This is attributed by Hermann to the fact of the transverse polarised current disappearing more rapidly than the longitudinal on account of the comparative approximation of the electrolytes. That the resistance in the transverse direction is due to internal polarisation seems probable also from the fact that the polarisation increases to a maximum with strengthening of the current, and again diminishes.

ELECTRICAL STIMULATION OF NERVE AND MUSCLE. — Willy (*Pflüger's Archiv*, v. 275—280) investigates the influence which the length of the intrapolar region exerts on the stimulation of nerve by electricity. The irritation increases the nearer the cathode is brought to the muscle, and the further the anode is removed. This is always true of a stimulation by closure of the current, but has exceptions in the case of stimulation by opening the current.——Eulenburg (*Berlin. Klin. Wochenschrift*, No. 21, 1872) obtains the strongest stimulation of nerve, both from the cathode in closure of the current, and from the anode in opening, when he places one pole on another nerve of the same plexus, or on the corresponding spinal centre. In this way a greater intrapolar length is obtained.——Du Bois Reymond (*Reichert u. du Bois's Archiv*, 1871, 561—567) 'On the influence of extra-conduction (neben-leitungen) on the current in the gastrocnemius of the frog.'——'Directions for the use of the round compensator.' (*Ibid.* pp. 608—618).——Fuchs (*Zeitschrift f. Biologie*, VIII. 1, 100—123, 1872) investigates the laws of nerve-stimulation with unipolar currents.

SENSATION.

VISION WITH COMPOUND EYES. Boll (*Reichert u. du Bois Reymond's Archiv*, 1872, H. 5, pp. 530—549) investigates the conditions of vision in animals which possess compound eyes in special reference to the question whether, as I. Müller supposed, the individual facets each form an image of individual parts of the objects only, or whether, according to more recent researches, each facet forms a complete inverted image of the whole object. The latter view would necessitate the supposition that behind each facet there is a kind of retina, a supposition not altogether in harmony with the microscopical researches of Max Schultze. Though nerve-fibrils may be traced to the central end of each crystalline cone, still they do not form a structure analogous to a retina. The crystalline cones of the eyes of anthropoda do not seem to be adapted for forming images, but they refract light, so that the light falling in the axis of the cone can be concentrated on the end of the nerve-fibril, and the light from neighbouring parts excluded. Boll agrees with the view expressed by Müller. It would thus appear that the compound eyes are not to be regarded as an aggregation of simple eyes. The cornea and crystalline cone of the anthropoda are not analogous to the cornea and vitreous humour of the vertebrate eye, but rather, that the cornea of the compound eye is analogous to the bacillary layer of the vertebrate retina.

PERCEPTION OF SPACE IN THE SKIN OF THE LOWER EXTREMITY. Paulus (*Zeitschrift f. Biol.* VII. 237) in continuation of the research of Kollemkamp and Ullrich (see p. 210, Vol. V. of this *Journal*) examined at Vierordt's suggestion the sensibility of the skin of the lower extremity. This differs from that in the arm, for in the latter it steadily increases from the shoulder downwards to the hand, while in the former, it increases from the hip downwards to the knee, and from the ankle onwards along the back of the foot and great toe. In the leg, however, the sensibility is least midway between the knee and ankle, and increases upwards to the knee, and downwards towards the ankle. The increase is more rapid in the latter than the former direction. The skin over the joints is very sensitive.

Circulatory System.

ACTION OF THE RIGHT AND LEFT VAGUS. Masoin (*Bull. de l'Acad. roy. de Médicine de Belgique*, T. VI. 3 Serie, p. 4) and Arloin and Tripier (*Arch. de Physiol. Norm. et Path.* July, 1872), from experiments on rabbits and a pigeon, have found, independently of each other, that the right vagus has a much more powerful inhibitory action on the heart than the left. This action is exerted equally over every part of the heart. A year or two ago A. Bernhard Meyer (*Das Hemmungsnervensystem des Herzens*, 1869, p. 61) observed that the left vagus of a tortoise (*Emys lutaria*) obtained from certain districts in Germany had no inhibitory action on the heart whatever, while the right vagus had a powerful one. In specimens of the same species obtained from Italy the left vagus had a slight inhibitory action.

INNERVATION OF THE HEART.—Schmiedeberg (*Ludwig's Arbeiten*, VI. 34) discusses the anatomy and physiology of the cardiac nerves in the dog. The investigation presented great difficulties from the numerous vessels which must be divided before the nerves are exposed. The experiments were made entirely on the nerves of the right side. As is well known the vagus and sympathetic are united in the neck of the dog into one common trunk, the vago-sympathetic, which descends along the carotid artery to the last cervical ganglion. This ganglion is the point of junction where the nerves not only of the heart but of other organs meet, and whence their fibres, after becoming mixed together in various ways, pass on to their several destinations. The chief nerves in relation with this ganglion are (1) Two filaments which connect it with the first dorsal. (2) The vagus trunk which passes onwards from it. (3) The recurrent laryngeal. (4) The superior cardiac nerve. (5) The inferior cardiac nerve. These latter three either spring from the ganglion or its immediate neighbourhood. In describing the anatomical relations of these nerves he mentions that (1) the second or undertwig of the two connecting filaments sometimes joins the vagus instead of the lower cervical ganglion. (2) The recurrent laryngeal either springs from the lower end of the ganglion, or from the trunk of the vagus near it. At the point where it bends round the subclavian it gives off one or more branches which form a plexus with several twigs proceeding from the vagus below the ganglion. Its ascending part is connected with the ganglion by a tolerably strong filament opposite to it. (3) The superior cardiac nerve may either spring from the lower cervical ganglion itself, from the upper twig connecting the two ganglia, or from the vagus immediately below the ganglion, and passes along the innominate to the heart. (4) The name of inferior cardiac nerve is given to a branch which springs from the vagus near the ganglion, but below the origin of the recurrent instead of above it, like the superior cardiac branch. Frequently only one or other of the cardiac nerves is present. They only differ in their position, and their functions are sometimes exercised by the one, sometimes the other. Besides the nerves above mentioned, the functions of the vago-sympathetic and of the filaments which pass from the spinal cord along the vertebral artery to the 1st dorsal ganglion, or roots of the ganglion, were investigated. The accelerating fibres which Rutherford found in the vago-sympathetic seem not to be contained in it above the inferior cervical ganglion. It contains afferent fibres which cause increased blood-pressure, and sometimes a quickened pulse. The roots of the first dorsal ganglion contain efferent vaso-motor fibres which regulate a large vascular district. Accelerating fibres could not be shown to exist in them, but this might be due to their action being counteracted by the increased blood-pressure. They contain dilating fibres for the pupil. A peculiar phenomenon was observed during their irritation which renders it not improbable that they contain vaso-motor nerves for the pulmonary vessels. During stimulation the blood-pressure rose and the pulse became slow. Both effects disappeared after the irritation was discontinued, but in a few seconds again re-appeared in a more marked manner than even during the irritation, and after lasting a few seconds again vanished. (1) The filaments connecting the two ganglia contain efferent fibres which accelerate the heart, but hardly influence the blood-pressure, and afferent fibres which cause acceleration of the heart, and sometimes a rise in blood-pressure. It is not certain whether this acceleration is reflex or not. The functions of the roots are not always distributed in the same way between the filaments, for irritation of the central end of the under twig at one time quickened the pulse, while irritation of the upper one slowed it and raised the blood-pressure; at another time irritation of the upper one quickened the pulse while that of the undivided under one left it unaltered but raised the blood-pressure. The vagus trunk below the ganglion contains sometimes inhibitory fibres (efferent) alone, sometimes a mixture of inhibitory and accelerating. The recurrent sometimes contains efferent accelerating fibres alone, sometimes inhibitory fibres alone, and sometimes a mixture of both. It contains afferent fibres which raise the blood-pressure. The superior and inferior cardiac nerves may either contain inhibitory fibres alone, or accelerating fibres alone. The inferior nerve may also contain a mixture of both, and afferent fibres which cause increased blood-pressure. Inhibitory fibres are more easily excited and more easily exhausted than accelerating fibres, and therefore when a nerve containing both is stimulated, the pulse is at first slowed, but gradually becomes quicker and quicker, as the stimulation is continued, and the accelerating fibres begin to assert their preponderance over the inhibitory ones. Stronger currents are required to stimulate the accelerating than the inhibitory fibres, and while the latter may be paralyzed by numerous poisons, none is known which destroys the former, their action remaining perceptible on the pulsating parts of the frog's heart after poisoning by digitaline or veratria. The accelerating nerves have often no influence whatever on the blood-pressure. During their action the pulse waves diminish in size. It is probable, though not certain, that this is due to imperfect dilatation of the heart during diastole. It is uncertain whether the diminution of the pulse-wave depends on the quickness of the pulse, or *vice versâ*, since they occur simultaneously through the heart of the dog. In that of the frog the wave becomes altered before the pulse-rate.

ON PECULIARITIES OF THE IRRITABILITY OF THE MUSCULAR FIBRES OF THE HEART.—H. P. Bowditch (*Ludwig's Arbeiten*, VI. p. 139) made use of the excised heart of the frog for his experiments on this subject. A glass cannula was passed into the ventricle from the auricle, and the lower two-thirds of the ventricle separated from the auriculo-ventricular groove, and therefore from the chief cardiac ganglia, by a ligature firmly tied round it. The ventricular apex was filled with serum, and suspended in a vessel also containing serum. It was irritated by shocks from an induction coil, and its contractions registered by a small mercurial manometer. For a description of the apparatus we must refer to the original. When the pulsations are equal in number to the irritations applied, he terms the pulse regular, when fewer, intermittent, and when more numerous, supernumerary. The supernumerary pulse was very rare, and generally appeared only when the ligature round the ventricle was not sufficiently low. When weak shocks are used, the pulse is intermittent, but as their strength is increased it becomes regular. It can be also rendered regular by increasing the interval between the shocks, instead of increasing their strength. Although the strength of the shocks necessary to produce a regular pulse may be diminished if the interval between them is increased, the diminution cannot be carried far without producing intermittence. It thus appears that great intervals of time are compensated by small differences in the strength of the irritant. The sensibility of the heart becomes increased after the repeated application of the irritant, so that after some time weaker shocks than at first suffice to produce a regular pulse. The amount of contraction has no relation to the mode of its recurrence. An irritation, which is only sufficient to produce an irregular pulse, suffices to excite the maximum contraction of which the ventricle is capable. An irritation, which produces a contraction each time, he terms infallible (unfehlbar), one which is able to produce the maximum contraction, but only occasionally, he calls sufficient (hinreichend). Exhaustion is not the reason why a sufficient irritation is not always infallible. The ligature round the ventricle has probably an inhibitory action, and when a second one is applied a stronger irritation is required to produce regular pulse. When fresh serum is supplied a weaker irritation is often sufficient. The amount of each contraction depends much on the time between it and the preceding one. A succession of infallible irritations produce a series of contractions, each greater than its predecessor, to which he gives the name of a stair (Treppe). The form of the stair, the minima and maxima of the contractions, are independent of the direction and strength of the induced current. The length of the interval between two shocks greatly influences the amount of contraction. When there is a short interval only between two shocks, but a long one between each pair, the contraction induced by the second shock of the pair is always greater than that of the first. The minimum and maximum height of the stair is also regulated by the interval, the height of the lowest step diminishing as the interval increased, and the greatest height being attained at an interval of between 4 and 5 seconds, and diminishing with an interval either greater or less. The power of a heart exhausted by constant contraction can be partially restored several times by the introduction of fresh serum, but after each successive introduction the heart has less power, and is more easily exhausted. The exhausted heart differs from the fresh one only in the amount of its contractions and the length of time it can work. The stair-like increase in the amount of its contraction, and its dependence on the interval between the irritations, are observable in it, just as in the fresh one. When a weak solution of salt and gum was used, instead of serum, the stair-like appearance was absent, the height of the first contraction after an interval increasing with its length, and being greater than that of succeeding contractions. Muscarin diminished the height of the contractions and increased the stair-like appearance. In hearts poisoned by it the height of the curve increased as the interval diminished. Atropia nearly destroyed the stair-like appearance and increased the height of the contractions. The greatest height was obtained after a long interval. Delphinia in large doses destroys the irritability of the heart at once, small ones lessen it, so that an irritant sufficiently strong to be infallible only produces intermittent contractions. The stair disappears. Contractions also take place without external irritation; sometimes these occur when the most powerful shocks have lost all effect. Increased temperature causes diminution in the amount of contraction. This is not hindered by atropia. A ligature round the auricle increased the stair-like appearance.

Inhibition of the Heart's Action in Mollusca.—M. Foster (*Pflüger's Archiv*, v. pp. 191—195) describes a peculiar inhibitory action he has observed in the heart of Anodon and Helix. He found no nerve corresponding to the vagus. By direct irritation of the heart, when entirely removed from the body, by means of weak induced currents a condition of stoppage in the state of diastole was produced. When the current was increased in strength, first vermicular movements, and then tetanus resulted. During the stoppage of the heart electrical and mechanical stimuli have the power of exciting it. The facts are explained by the molecular condition of the contractile tissue of the heart itself, apart from nervous influence. Atropin, as in the vertebrate heart, paralyzes the inhibitory mechanism, and causes the systole to be remarkably prolonged.

Method of Obtaining Lymph in Large Quantities.—Lesser (*Ludwig's Arbeiten*, vi. 94) obtains lymph by inserting a cannula into the thoracic duct of dogs paralyzed by the injection of a small quantity of curare repeated from time to time. Lymph flowed in an almost unbroken stream from the duct, even when the animals on which he experimented had fasted for 24 hours, and the limbs were perfectly motionless. Variations in the rapidity of the stream occurred with a certain regularity. In some experiments, the flow underwent a gradual diminution from the beginning to the end, in others it was at first slow, and became gradually quicker till near the end, when it again grew slower. For a long time (as much as 69 minutes) after the cessation of the cardiac pulsations the lymph continued to flow almost as rapidly as before. This must have been due to the passage of fluid from the tissues into the lymphatic vessels, which was probably caused by the intermittent pressure exerted by the movements of artificial respiration on the abdomen, producing a similar effect to alternate extension and flexion of the joints (see Genersich, in this *Journal*, vi. 228). In other experiments such passive movements were made on the posterior extremities. Like Genersich, he found that they increased the quantity of lymph. They also altered its quality, that which flowed during rest being opalescent, while during the continuance of passive movements the opalescence became very slight or disappeared altogether. The stream from the thoracic duct of a dog, which had been fed, was somewhat less during rest than from that of a fasting animal. Fasting animals, without movement, generally die without apparent cause, after large quantities of lymph, corresponding to $\frac{1}{7}-\frac{1}{4}$ of the total quantity of blood, have been taken from them. When passive movements of the lower extremities are made, a much larger quantity (as much as 23 per cent.) can be withdrawn without death ensuing. The blood is concentrated by the removal of lymph, its colour becoming more intense, and its power of taking up oxygen increased. Loss of lymph, therefore, acts differently on the blood from loss of fluid by the urine or sweat, which does not alter its composition. The difference is probably due to the difference in the forces which govern the secretion of the lymph and urine. The serum of the blood, after the extraction of a large quantity of lymph, was found in one instance to contain less water and ash, and more organic substance. The blood-pressure, instead of being lessened by the loss of lymph, was generally increased by it.

INJECTION OF THE BLOOD-VESSELS IN COLEOPTERA.—Moseley (*Ludwig's Arbeiten*, VI. 60) proceeds to inject the blood-vessels in large beetles, such as Dytiscus marginalis, Hydrophilus piceus, Melolontha vulgaris, by cutting the elytra straight across while the insect is alive, and observing at what point in the section the largest drops of blood make their appearance. The position of the largest vessel being thus ascertained, he inserts into it a fine glass cannula. To the outer end of this a piece of india-rubber tubing is connected, and both it and the cannula are filled with the injecting fluid. The outer end of the tubing being closed, the fluid it contains is forced into the vessel, either by pressure with the fingers, or by a small weight. By inserting the cannula into the vessels of the severed end of the elytra, or the part still connected with the body, either the elytra alone, or the whole insect, may be injected.

Temperature.

ANIMAL HEAT.—Horvath (*Centralblatt*, No. 45, 1872) publishes an instalment of his observations on hybernating animals, concerning the condition of which, during their winter sleep, there are many contradictory statements. He has made his observations in Russia, on the souslik marmot (Spermophilus Citillus). He finds that these marmots do not sleep continuously the whole winter, but occasionally wake up, so that they would sleep from one to four days, and remain awake for a similar period. This irregularity in the sleep enabled him to make some very interesting observations regarding the temperature of these animals in their different states. The internal temperature of the souslik during the waking condition, as determined by the thermometer, in the rectum, was from 35—37° C. During the state of hybernation the temperature is the same as that of the surrounding medium. Horvath observed a marmot, which a short time before had an internal temperature of only 2° C. awake, and become lively and active. He gives this as the only example on record of a warm-blooded animal surviving a temperature so near the freezing point.

ON ABSORPTION OF HEAT DURING INCUBATION.—Moitissier (*Comp. Rend.* LXXIV. 54) noticed that when eggs are warmed to 41° C., and then allowed slowly to cool, those in process of hatching cool more quickly than others down to 35° or 36°, at which temperatures they remain for ten or fifteen minutes, and then they become gradually colder, just like those in which no chick was contained. This phenomenon is ascribed by the author to part of the heat between 41° and 36° being absorbed, and applied to the development of the embryo. The specific heat of incubated eggs seems less than that of others.

Digestive System.

Secretion of the Submaxillary Gland. — R. Heidenhain (*Pflüger's Archiv*, v. 40—47) describes the action of some poisons on the submaxillary gland, of great interest in a physiological point of view. When atropin is injected into the circulation, in doses sufficient to cause paralysis of the inhibitory action of the vagus, paralysis of the chorda tympani is also induced, so that irritation of this nerve no longer causes increased flow of saliva, although the the rapidity of the blood-stream in the veins remains unaffected. This shows that the secretion of this gland is independent of the circulation. The action is not due to paralysis of the secreting elements of the gland, inasmuch as irritation of the sympathetic produces the usual results. The cells are therefore in full functional activity, but their innervation by the chorda must be different from that by the sympathetic. Calabar bean stimulates the chorda, and removes the paralysis caused by atropin, but if given in large doses, this effect is apparently counteracted by changes induced in the circulation, from irritation of intraglandular vaso-motor centres, so that the stoppage of the blood-flow leads to resistance and paralysis of the secretion. Nicotin at first stimulates the chorda, and causes salivation, but ultimately causes complete paralysis of the secreting and vaso-inhibitory power of the chorda. Digitalin increases the flow of saliva by stimulating the central end of the chorda. Large doses do not cause paralysis.

Formation of Pepsin in the Stomach.—Ebstein and Grützner (*Pflüger's Archiv,* vi. p. 1) find that the pyloric part of the stomach contains pepsin. On separating the superficial from the deep layer of the pyloric mucous membrane, the latter was found to digest more actively than the former. As the chief cells (hauptzellen) of Heidenhain are the only cells in the pyloric end of the stomach, and are more abundant in its deeper layers, the authors consider, in opposition to Friedinger, that the formation of pepsin takes place in them.

Physiology of Vomiting.—Hermann and pupils (*Pflüger's Archiv*, v. 280—282) investigate the physiology of vomiting, in special reference to the experiments of Grimm (see *Journ. of Anat. and Physiol.*, No. ix. p. 242). They find that tartar emetic acts more slowly when introduced directly into the blood than when introduced into the stomach. Hermann attributes the vomiting to direct irritation of the stomach by the drug, and not to direct action on a "vomiting centre." The fact that tartar emetic may cause vomiting, even after the extirpation of the stomach, as in Magendie's experiment, is explained by reflex irritation from the mucous membrane of the pharynx and intestine.

FORMATION OF GLYCOGEN IN THE LIVER.—Dock (*Pflüger's Archiv*, v. 571), in a series of experiments performed by him under Hermann's direction, found that when rabbits are deprived of food for several days glycogen disappeared completely, or almost so, from their livers. After a few injections of sugar into the stomach, glycogen again became abundant in the liver in all but one instance. Injections of water or albumin did not produce glycogen. Glycogen did not appear in the liver, or only in traces after the injection of sugar into the stomach, if the floor of the fourth ventricle had been previously punctured in three instances. In a fourth case glycogen appeared notwithstanding the puncture. Although no glycogen was formed in those three cases, sugar did not appear in the urine after its injection into the stomach. In animals poisoned by curare, and kept alive by artificial respiration, injections of sugar into the stomach were not followed by the formation of glycogen in the liver, but sugar was found copiously in the urine. Poisoning by curare produced diabetes in animals which had fasted so long that all the glycogen must have disappeared from their livers, although no sugar was injected into the stomach.

THIRY'S FISTULA.—Albini (Alcune considerazioni sulla fistola intestinale secondo il metodo di Thiry, abstracted in *Henle and Meissner's Jahresbericht* for 1871, p. 113) finds that the piece of intestine isolated in Thiry's fistula becomes atrophied although its nerves and vessels are intact.

Urinary System.

Solowieff (*Centralblatt*, No. 22, 1872) describes the histological changes which result in the liver from gradual obliteration of the portal vein. According to the length of time that the animals have lived changes are observed in the vessels, the hepatic cells, and the connective tissue. For details reference must be had to the original paper.

A NEW METHOD OF INDUCING DIABETES.—Bock and Hoffmann (*Reichert u. du Bois's Archiv*, 1871, 550—560) produce diabetes in rabbits by injecting rapidly large quantities of a one per cent. solution of common salt into the carotid or femoral artery. Melituria was always preceded by polyuria. The amount of sugar gradually rose to a maximum, and then gradually disappeared. At such period the liver gave neither sugar nor glycogen on analysis. On these facts the authors base a hypothesis that it is the result of nervous influence or change in the circulation. Further research is promised. ——Küntzel (*Inaug. Diss.* Berlin, 1872, *Centralblatt*, No. 44, 1872) obtains the same result with other solutions such as do not act as direct poisons, viz. various sodium salts, and also gum-arabic.——Tiegel in a research "On a ferment-action of the blood" (*Pflüger's*

Archiv, VI. pp. 249—266) makes some observations which have a bearing on the preceding. He finds that the blood-corpuscles when undergoing destruction possess a diastatic action on glycogen. This takes place in the liver. He thinks that diabetes may be induced in three ways.

(1) When the glycogen is not increased, but when the destruction of blood-corpuscles is more rapid than usual. To this class belong Harley's experiments of injecting chloroform, &c. into the blood.

(2) It may result without increase in the glycogen or increased destruction of the blood-corpuscles, simply if more glycogen is dissolved. To this he attributes diabetes caused by injections of one per cent. salt solution into the arteries.

(3) Diabetes may be produced by injecting glycogen into the vessels.

Skin.

CUTANEOUS RESPIRATION.—Röhrig (*Deutsche Klinik*, No. 23, 25, 1872) gives the results of investigations on the cutaneous respiration. He finds that in the mean temperature the skin excretes 38 mgm. of CO_2 and 1·91 of water per hour. This is increased by food and also by increased temperature, as well as by irritants applied to the skin. He found also that the quantities of CO_2 and water given off &c. have very much increased during an attack of bronchial and nasal catarrh. He thinks that gases may be absorbed by the sound skin. A rabbit whose body was enclosed in a vessel of sulphuretted hydrogen in such a manner that it could only gain access to the system though the skin died with symptoms of poisoning by this gas. Chloroform also was found to exert a narcotising influence through cutaneous absorption. In another paper (*Archiv d. Heilkunde*, XIII. 341—388) Röhrig gives the results of experiments on cutaneous absorption. Turpentine is readily absorbed, as well as camphor. They are readily recognised in the urine. Conia placed on the shaved skin of a rabbit caused death in twenty-eight minutes. Many other substances also are shewn to be capable of absorption by the unbroken skin.—Von Paalzow (*Pflüger's Archiv*, 1872, p. 492) finds that baths of water rich in carbonic acid do not increase the respiration. He finds, on the other hand, that powerful irritation of the skin, such as is produced by mustard, causes increase both in the amount of carbonic acid evolved and oxygen taken in.

SUPPRESSION OF PERSPIRATION.—Socoloff (*Centralblatt*, No. 44, 1872) gives an abstract of the results which follow varnishing the skin and suppression of the cutaneous secretion.

(1) A few hours before the death of the animals so treated, clonic and tetanic spasms appear in various groups of muscles, while the temperature in the rectum sinks in a marked degree.

(2) Enveloping the animals in wadding did not serve to raise the temperature or arrest the fatal result.

(3) Respiration of oxygen proved ineffectual to resuscitate the animals.

(4) In the stomach ulcers were observed, the result of deep extravasations.

(5) Albumen appeared in the urine very soon after the skin was varnished.

(6) In all cases a diffuse parenchymatous inflammation of the kidneys was observed—sometimes swelling of the cells, and sometimes fatty degeneration. This result was independent of the nature of the varnish used, whether turpentine varnish, or gelatin, or gum.

Lang (*Arch. d. Heilkunde*, XIII. pp. 277—287, 1872) investigates the cause of death when the skin has been varnished. In addition to other phenomena he found an hour or two after death 'triple phosphate crystals' in various parts of the body, and some of the uriniferous tubules blocked with a finely granular dark mass. He thinks that the triple phosphate crystals are the result of decomposition of urea, and that the cause of death is uræmia.

Muscle.

A full report of an important paper on muscle by H. Kronecker (*Ludwig's Arbeiten*, VI. 177) will appear in our next number.

Miscellaneous.

ON THE GASES OF DOG'S LYMPH.—Hammersten (*Ludwig's Arbeiten*, VI. 121) finds that dog's lymph contains on an average 35·38 per cent. of carbonic acid, which is not simply absorbed, but is in a state either of loose or firm combination. It contains no oxygen, or only traces of it. Oxygen may, however, be present in it without being consumed. Its nitrogen amounts to 1·17 per cent. on an average. In order to discover whether the easily oxidizable substances found by A. Schmidt in the blood of asphyxiated animals, were formed in the tissues, in which case they would be present in the lymph, or were formed in the blood itself, lymph and arterial blood were mixed together, and the gases analyzed after some time. If the lymph contained oxidizable substances the O of the blood would be diminished and the CO_2 increased. The experiment showed that the lymph from the body generally contained almost no oxidizable substances, although it is possible that they may be present in the lymph of special organs.

PERMEABILITY OF THE CORNEA TO FLUIDS.—Laqueur (*Centralblatt f. d. med. Wiss.* 1872, p. 577) finds that fluids do not pass through the cornea of an excised eye, so long as it is covered with epithelium, but pass readily either from within outwards, or *vice versâ*, when the epithelium is removed. Descemet's membrane is permeable to fluids as well as the substance of the cornea. The periphery of the cornea is more permeable than the centre. The diffusive power of the anterior epithelial layer of the cornea during life differs from that of the excised eye, since a solution of atropia passes readily through the former.

FIXATION OF THE ARYTENOID CARTILAGES DURING PHONATION.—Jelenffy (*Wiener Med. Wochenschrift*, 1872, Nos. 3 and 4) has discovered, by experiments on the excised larynx, and by observations in three cases of paralysis of the muscles of vocalization, and one of spasm of the glottis, that the arytenoid cartilages are fixed in the first instance on the cricoid by the combined action of the arytenoidei postici and laterales, which draw them inwards and downwards. The arytenoidei laterales then turn the cartilages on their vertical axes by drawing the muscular processes forwards. The vocal processes, which form the other end of a two-armed lever, are consequently pulled backwards and fixed. As soon as this is effected the vocal cords can be rendered tense by the cricothyroid muscle.

NEW METHOD OF ESTIMATING THE LIME AND PHOSPHORIC ACID IN SERUM.—Pribram (*Ludwig's Arbeiten*, VI. 63) obtains serum in large quantities, by collecting blood directly from the vessels in long glass cylinders, cased in lead, which, as soon as coagulation has taken place, are laid in the drum of a centrifugal machine, the bottoms of the cylinders being directed outward. The drum being then made to rotate with considerable speed, the clot is driven outwards to the bottom of the cylinder and the serum collects at its upper end. The serum thus obtained is freed from blood corpuscles by treating it a second time in a similar manner. In order to estimate the calcium it was precipitated by ammonium oxalate. As this precipitate subsides very slowly from serum, and cannot be collected by filtration, the fluid was again placed in the centrifugal machine, and in half-an-hour the oxalate was obtained as a firm layer at the bottom of the cylinder. After washing the calcium in it was determined in the usual way. The remaining serum passed readily through a filter, and the clean filtrate was precipitated by ammonio-magnesium phosphate. This precipitate was also separated by the centrifugal machine, and then weighed as magnesium pyro-phosphate.

Almost the whole of the calcium, but less than one-third of the phosphoric acid contained in the serum, is precipitated by this method. Even were it possible that tribasic calcium phosphate could be kept in solution by some organic substance present in the serum, the phosphoric acid precipitated would be insufficient to form this salt, and at least a part of the calcium must therefore be combined with something else, but whether this is albumin or not is uncertain. The presence of lime as phosphate in the serum is also rendered improbable by the fact that the greatest part of the phosphoric acid can be extracted by alcohol.

A CERTAIN SIGN OF DEATH.—Magnus (*Virchow's Archiv*, LV. 511—517) gives as a certain sign of death the complete cessation of the circulation, as determined in the following manner. If a finger is tightly ligatured even when life is at its lowest ebb there is observed at the point of ligature a white circle, due to arterial anæmia, while the part beyond the ligature gradually becomes red, and ultimately livid from venous hyperæmia. In the dead body these phenomena do not manifest themselves.——M. Rosenthal (*Wien. Med. Presse,* Nos. 18—19, 1872) investigates the CHANGES IN ELECTRICAL EXCITABILITY IN THE MUSCLES AFTER DEATH. Shortly after death—from one-and-a-half to three hours—the reaction of the muscles to electrical stimulation disappears. He thinks that in cases of apparent death electrical exploration of the muscles will be of great value. He mentions a case in which he in this way diagnosed apparent death lasting forty-four hours, and thus prevented burial.

THE SPHINCTER VESICÆ.—Kupressow (*Pflüger's Archiv,* v. 291—294) measures the resistance offered by the sphincter vesicæ by a column of water acting from the ureter. In rabbits the sphincter is forced by a pressure of from 40—50 cm. Section of the spinal cord between the fifth and seventh lumbar vertebræ causes the resistance to sink to 12—16 cm. The centre of innervation of the sphincter lies between the fifth and sixth lumbar vertebræ. The retention of urine in the bladder is attributed by Budge to the urethral muscles alone. This is not the case, though they aid the true sphincter. Slitting up of the urethra causes a sinking of the column one half in male rabbits, and one fourth in female.

DR FRASER'S REPORT.

Physiological Action of Medicinal and Poisonous Substances.

BROMIDE OF POTASSIUM.—Believing that this salt forms the efficient agent in Bibron's antidote, Dr E. A. Anderson administered it freely in two cases of snake bite (*American Journal of the Medical Sciences,* April, 1872, p. 366). Both cases recovered; and the opinion is expressed that death would have occurred had the bromide not been given. It is said, especially, to have promptly allayed pain and to have produced sleep. (Along with it, however, very considerable doses of alcohol were given; and this introduces an obvious fallacy in estimating the value of the antidote, even although it were granted, which it cannot be, that a sufficient quantity of the venom had been introduced to cause death in the absence of all treatment.)

MERCURY.—Dr H. Byasson has made some experiments (*Journal de l'Anatomie et de Physiologie,* No. 5, 1872, p. 500) for the purpose of ascertaining within what time a soluble salt of mercury, introduced by the stomach, appears in the urine, saliva, and perspiration of human beings. The mercury was given in the form of perchloride, in doses of 0.15 gr., combined in a pill with 0.015 gr. of hydrochlorate of morphia; and its presence in the fluids mentioned was detected by a delicate yet simple process of analysis described in the previous number of Robin's *Journal* (p. 397). The experiments led to the following conclusions:—1. Perchloride of mercury, administered by the stomach, can be detected in the urine about two hours after its administration. 2. In the saliva in about four hours. 3. It does not seem to be discoverable in the perspiration. 4. Its elimination may be regarded as finished in twenty-four hours after administration.

CHLORAL.—Among other statements regarding the effects on rabbits of non-lethal and lethal doses of chloral, exhibited by subcutaneous injection, Dr A. Edward M^cRae (*Edinburgh Medical Journal*, August, 1872, p. 133—149) makes the following:—Sleep was sometimes produced by 10 grs.; sometimes, however, 30 grs. had scarcely any effect; death resulted, in two experiments, from 60 grs., but in another experiment this dose did not prove fatal[1]. About four minutes elapsed between the injection and the manifestation of the first symptoms. These consisted of increase of the number of the respirations, immediately following the injection, then slowing with jerkiness of character until sleep was produced, and still further slowing until death, which always occurred when the rate had diminished to 28 per min.; the production of hyperæsthesia with all the doses that were given, followed by anæsthesia when the doses were lethal; loss of special sensibility, vision being affected before hearing, hearing before smell, and smell before touch; and distinct elevation of temperature when small doses were given, but diminution of temperature when the doses were large. Shivering was not observed in any experiment where death supervened, but it preceded resolution in non-fatal experiments. Salivation occasionally occurred, and likewise relaxation of the sphincters, with increased peristalsis of the bowels and bladder. Rigidity set in immediately after the respirations ceased. The injection of the above doses almost always caused local inflammation, which ended in resolution, suppuration or gangrene. In the fatal experiments, the superficial blood-vessels were empty; while the internal vessels were full of blood; the walls of the heart were flaccid, and both sides were gorged with blood; the lungs were congested, with here and there apoplectic spots; the vessels of the encephalon were full of blood; and the odour of chloral was distinctly perceived in the substance of the brain.

CHLORAL-SULPHYDRATE.—By submitting anhydrous chloral to the action of sulphuretted hydrogen, M. Henri Byasson obtained a white crystalline substance, having a disagreeable odour, and a peculiar taste suggestive of anhydrous chloral (*Journal de l'Anatomie et de la Physiologie*, No. 3, 1872, p. 297). An analysis of this substance has led M. Byasson to propose for it the formula $C^4\ HCl^3\ O^2$, 2 HS. Under the influence of hydrated alkalies or ammonia, it is decomposed in an analogous manner to chloral, as is shown by the equation,

$$C_4\ HCl_3\ O_2,\ 2\ HS + 2\ (KO,\ HO) \quad C_2\ HCl_3 + C_2\ HKO_4 + KS,\ HS + 2\ HO.$$

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[1] Unfortunately no information is given regarding the weight of the animals.

It is decomposed also by water and alcohol, which renders difficult the examination of its physiological action. By dissolving it in ether, however, M. Byasson was able to administer it to guinea-pigs. He found that, in non-lethal doses, it produces diminution of temperature to about one degree Cent., muscular resolution, and sleep lasting about two hours, without any notable alteration of sensibility, but with slight acceleration of the rate of the heart's contractions. At the end of the sleep the animal quickly recovers its normal condition.

Formic Ether.—In a research on chloral hydrate by MM. Byasson and Follet (see *Journal of Anatomy and Physiology*, vi. 1872, p. 493), the opinion is expressed that a certain portion of the action of this substance depends on the formic acid which is produced under the influence of the alkaline salts of the blood. This opinion was difficult to prove because the formiates are physiologically inert. It was important, therefore, to find a substance which produces formic acid as a result of its decomposition. M. Byasson (*Comptes Rendus*, 29 April, 1872, p. 1202) now publishes the result of some experiments with formic ether, a substance that fulfils the required indications, as it is readily converted by alkalies into alcohol and a formiate. When this substance was administered to animals by inhalation, it rapidly affected them, but not so rapidly as chloroform; and the symptoms were those of asphyxia, with lowering of the temperature, incomplete muscular flaccidity, and diminution, without total suspension of sensibility. Return to a normal state was not accomplished until several hours. Similar symptoms were pronounced by subcutaneous injection. In an experiment on man, where the administration caused a marked tendency to sleep, formic acid was detected in the urine. By way of comparison, acetic ether was given in similar experiments, but no decided effect was observed. M. Byasson believes that these results confirm his previously expressed opinion, that the physiological action of chloral hydrate is not the same as that of chloroform introduced into the blood in small successive doses, but that it is an action special to that substance, resulting from the combined actions of the chloroform and the formic acid which are produced in the economy under the influence of the alkaline carbonates of the blood.

Cyanates.—Continuing his important researches on the transformations undergone by substances introduced into the system, Dr Rabuteau has made some experiments (*Journal de l'Anatomie et de la Physiologie*, No. 3, 1872, p. 335) to discover if cyanates are poisonous, after they become reduced to cyanides; or if they undergo in the organism the same transformation they experience in contact with water. He finds that cyanates are not poisonous, and that in the body they produce alkaline carbonates, which may be detected in the urine. It is much the same thing, therefore, to administer an alkaline cyanate, or to administer an acetate, lactate or tartrate.

OPIUM.—The action of the chief immediate principles of opium has formed the subject of an elaborate research by Dr Rabuteau (*Journal de l'Anatomie et de la Physiologie*, No. 3, 1872, p. 302). Besides investigating the soporific, convulsant, toxic and analgesic effects of these principles, Dr Rabuteau has examined the influence they exert on the exosmosis of fluids into the intestinal canal, according to the method of Dr Moreau. His experiments in great measure confirm those of Claude Bernard respecting the soporofic, convulsant, and toxic power of these principles on the lower animals; but they seem to show that in man the relative prominence with which these actions are exerted is somewhat different than in the lower animals. This, and the other main results of his experiments, are shown by the classification of the opium principles according to their physiological action on man, which he has published:—In their order as *Soporifics:* morphia, narceia, and codeia; the other principles do not produce sleep. In their order as *poisons:* morphia, thebaia, codeia, papaverin, narceia, and narcotine. In their order as *analgesics* (pain-destroyers): morphia, narceia, thebaia, papaverin, and codeia; narcotine does not appear to lessen pain. In their order as *anexosmotics:* morphia, narceia; the other principles do not arrest diarrhœa. Dr Rabuteau further points out that opianin, a principle that is present only in minute quantity in opium, has an action very similar to that of morphia, and that meconin and meconic acid are devoid of physiological activity.

THE COMBINED EFFECTS OF OPIUM ALKALOIDS AND CHLOROFORM.—The statement of Claude Bernard and Nussbaum that by administering morphia and chloroform in combination very complete anæsthesia may be obtained with a quantity of chloroform greatly less than is required when chloroform is alone given, has received confirmation and extension from the observations of MM. Labbe and Guyon and Dr Rabuteau. The former observers mention (*Journal de Pharmacie et de Chimie*, Mai, 1872, p. 398) that among their other results they found that this combination produces an anæsthesia of long duration, which may be prolonged still further by successive small doses of chloroform. They believe, therefore, that by this combination the risk of fatal accidents is greatly diminished.—Dr Rabuteau, towards the termination of his paper on the opium active principles (*loc. cit.*), expresses his adherence to the statements of previous observers, and adds that nearly all the opium alkaloids, even those which are not soporifics, are able to continue the analgesic action of chloroform, because nearly all of them possess the power of lessening sensibility. Narcotine, however, is not able to do so; but he has found that narceia is nearly as efficient as morphia, while codeia and papaverin only feebly continue the action of chloroform.

APOMORPHIA.—The evidence in favour of the valuable emetic properties of apomorphia has received an important addition from the observations of Dr Siebert (*Archiv der Heilkunde*, December, 1871; and *Gazette Hebdomadaire*, No. 22, 1872, p. 366). He finds that this agent does not produce any effect on the digestive organs except the simple production of emesis. After its injection under the skin the pulse becomes irregular and slightly accelerated, and these changes are most pronounced at the moment of nausea and before vomiting, while after vomiting slowing takes place. In short, apomorphia affects the circulation in very much the same way as tartar emetic and ipecacuanha; a similarity that is further shown by the lowering of the temperature which succeeds the emesis. It differs from these substances, however, in being altogether destitute of irritant property; its injection under the skin does not produce inflammation, and neither diarrhœa nor disturbance of digestion follow its administration. Dr Siebert found that the minimum quantity requisite to produce emesis by subcutaneous injection is, in man, from 0.09 gr. to 0.1 gr., in cats 0.3 grs., and in dogs 0.015 gr. to 0.03 gr. He could not discover the maximum dose that can be given to cats and dogs without producing injurious effects, because even when doses 80 or 100 times as large as the above were given, there were no symptoms of cerebral disturbance. He believes that in man the dose may, without risk, be increased to 0.2 or even 0.6 gr. When given by the stomach much larger doses are of course required. Thus, a man of 49 years, took 0.95 gr. and only nausea resulted, and when he took 1.5 gr. emesis occurred without any injurious effects.

Quinia.—Several years ago Professor Binz made the extremely valuable discoveries, that quinia has the power of preventing putrefaction, that it is an energetic poison for low vegetable and animal organisms, and that it is able to arrest the movements of the white blood-corpuscles. The last of these discoveries has lately attracted great attention from its obvious relationship to Cohnheim's views regarding inflammation and suppuration, according to which pus is mainly a collection of white blood-corpuscles that have passed through the walls of the vessels. If quinia be able to arrest the movements of these corpuscles, it may be expected to exert a very beneficial influence as a remedy in inflammation. Many observers, accordingly, have turned their attention to this point. Of these, Stricker threw some doubts on the value of Binz's results, by suggesting that the arrest in the movements of the white corpuscles was simply the result of the acid contained in the solution of quinia that was employed. This criticism has induced Dr Kerner to reinvestigate the subject (*Centralblatt*, No. 9, 1872, p. 143). To avoid the objection raised by Stricker, he made use of perfectly neutral solutions of the hydrochlorate and carbonate of quinia. He mixed the blood of cats and dogs with a solution of one part of the salt in ten of water, in the proportion of one part of the solution to 4000 of blood, and found that the movements of the white corpuscles were immediately arrested, and that these bodies soon became rounded and granular. By way of comparison, he made a number of similar experiments with solutions of salicin, caffein, atropia, and arsenate of potassium, and he was able to satisfy himself that these substances exert no decided action on the white blood-corpuscles.——An elaborate series of researches by Dr Geltowsky (*Practitioner*, June, 1872, p. 321) confirms the more important of the statements of Binz, Kerner, and those who coincide in their views. In two points, however, Geltowsky differs from them: namely, in the degree of toxic strength of quinia—held by Binz, Kerner, &c. to be about 1 : 4000 of human blood, but by Geltowsky only 1 : 2800—; and in the possibility of obtaining the special effect on the white corpuscles by administering quinia to man.——Both of these differences are criticised in a recent paper by Professor Binz (*Practitioner*, September, 1872, p. 141). In reference to the first of them, Binz not only reiterates the statement that the proportion of one part of quinia to 4000 of blood is a sufficient one to destroy the movements of the white corpuscles, but he likewise gives the details of some experiments made with the blood of a leucocythemic patient, which showed that the white corpuscles of human blood may be paralysed by quinia in the proportion of one part of quinia to 10,000 parts of blood. In reference to the second point of difference, which Geltowsky has given expression to, by stating that "in the case of man, * * * it would be necessary, in order to obtain the special effect, to take almost one drachm of quinine, which would be impossible." Binz quotes the experience of Professor Socin of Bâle, who found it quite practicable to administer from six to seven grammes of hydrochlorate of quinia daily (6 grammes = about $1\frac{1}{2}$ drachm). He also states that it can never be our object to kill the white blood-corpuscles in the human body by quinia. They are necessary for life, and their death would be our death. All that is intended to be done to them is to decrease their number and the activity of their movements; and this can undoubtedly be done by quinia.

Strychnia.—Some observations by Brown-Séquard on the influence of carbonic acid in arresting epileptic convulsions promise to afford a valuable practical application in the treatment of strychnia poisoning (*Archives de Physiologie*, No. 2, 1872, p. 204). He finds that when epilepsy is artificially produced in guinea-pigs, the fit may be at once arrested by directing with considerable force a current of carbonic acid gas against the mucous membrane of the fauces. On account of the great sensibility of the mucous surface of the nares in man, he believes that the same result may be obtained in patients suffering from epilepsy by injecting this gas into their nostrils; and he recommends this treatment in poisoning by strychnia. Brown-Séquard asserts that Rosenthal has fallen into an error in ascribing the arrestment of respiratory movements, or of strychnia convulsions, by pulmonary insufflation to superoxygenation of the blood. He believes, on the contrary, that these results are due simply to mechanical irritation, by the forcibly inspired air, of the ramifications of the vagi nerves in the bronchi, and of the phrenic and other diaphragmatic nerves. The experiments which lead him to adopt this view show that when the spinal cord is divided above or below the origin of the phrenic nerves, or when the vagi nerves are divided, pulmonary insufflation no longer causes a cessation of the respiratory movements. In like manner, the forcible injection of carbonic acid acts as an irritant to the nerves in the air-passages, and an inhibitory influence is thereby exerted upon respiration and upon convulsive movements. Carbonic acid, which is an excitant of convulsions when acting upon the nerve centres, is thus, also, an arrester of convulsions when it acts upon certain of the mucous surfaces. The action is, however, in both instances the same: it irritates the nerve-elements (fibres or cells) with which it comes into contact. If these elements possess the power of producing convulsive movements, these movements occur; if, on the contrary, they possess the power of arresting the activity that causes convulsions, this activity ceases, and the convulsions no longer occur.

BELLADONNA.—In some interesting communications (*Practitioner*, August and October, 1872) Dr Sydney Ringer brings forward an abundance of evidence to prove that belladonna and its active principle are able to check and prevent sweating, whether the result of disease or induced by exposure to an elevated temperature. In the former case, his observations enable him to conclude that $\frac{1}{200}$th of a grain of atropia, injected under the skin, is generally sufficient to check sweating for one night. This dose produces dryness of the fauces, but it does not dilate the pupils. Stramonium, it was found, is able to exert the same influence.

CAMPHOR.—Dr John Harley describes some observations (*Practitioner*, October, 1872, p. 210) which appear to shew that camphor acts with but little energy on man. So large a dose as thirty-five grains merely caused giddiness, followed in thirty-five minutes by a full, bounding, but not accelerated pulse, by flushing of the cheeks, and by a little somnolency; all of which symptoms had nearly disappeared within two hours after the dose was administered. The vapour, he finds, acts with considerable energy as a poison on moths, and produces very decided hypnosis in mice.

ANTAGONISM.—(*Between chloral and strychnia.*) M. Oré, in a series of communications to the French Academy (*Comptes Rendus*, T. LXXIV. Nos. 24 and 26, T. LXXV. Nos. 1 and 4), describes a research undertaken to test the truth of Liebreich's statement, that strychnia is an antidote to chloral. He, in the first place, points out that Liebreich has omitted to determine the toxic dose of either of these substances with the required accuracy, and, accordingly, that he has fallen into the error of concluding that the same dose is sufficient to kill animals of different weights. Oré finds that the minimum-lethal dose of chloral, given subcutaneously, is about 60 grains, and that of strychnia 0.03 grains, for rabbits weighing four pounds. In a number of experiments, where this minimum-lethal dose of chloral was injected at various intervals before different doses of strychnia, he found that death always occurred, although in some instances its production was apparently postponed for some hours, by the influence of the strychnia. Oré concludes, therefore, that strychnia is not an antidote for chloral. At the same time, he found that the chloral had an obvious influence in preventing or diminishing the convulsive effects of the strychnia, but that this influence disappears when the dose of strychnia is increased beyond certain limits. (This research is not quite conclusive, as the doses of antidote (strychnia) were restricted to those extending from slightly below to considerably above the minimum-lethal).—(*Between physostigma and atropia.*) Dr Thomas R. Fraser has published (*Transactions Royal Society of Edinburgh*, Vol. XXVI. 1872, p. 529 –713) a continuation of his preliminary experiments on the antagonism between physostigma and atropia (see this *Journal*, Vol. IV. 1870, p. 168). By the result of a large number of experiments he confirms his previous statement, that atropia is able to prevent the fatal effect of large lethal doses of physostigma. He further shews that this antagonism is successfully exerted only within a well-defined range in the doses of the two substances. For the purpose of defining this range he performed three series of experiments: the chief objects of the first two of which were to ascertain the maximum dose of physostigma that can be successfully antagonised by atropia, and the range of doses of atropia that can successfully antagonise lethal doses of physostigma; while the chief object of the third series was to ascertain within what limits of time between the administration of the two substances successful antagonism occurs. The results obtained by these three series of experiments have been graphically represented in diagrams, in which the region of successful antagonism is mapped out.—(*Between physostigma and strychnia.*) An interesting case is described by Mr Ashmead (*Edinburgh Medical Journal*, September, 1872, p. 235) of strychnia-poisoning treated by physostigma. One drachm of solution of strychnia (= 0.5 gr. strychnia) had been taken, and recovery took place after the administration of a little more than two grains of extract of physostigma.—(*Between atropia and morphia.*) Careful details are given by J. Magee Finny (*Dublin Journal of Medical Science*, July, 1872, p. 38) of a case of atropia-poisoning successfully treated with morphia. Although there is no evidence to show that the dose of atropia was as large as the minimum-lethal one, and, therefore, that the morphia counteracted the lethal action of atropia, still the account of the case appears to show that very distressing atropia symptoms may be relieved by morphia.

ABSORPTION OF MEDICINAL SUBSTANCES BY THE SKIN.—By exposing the surface of the body to vapour obtained from water in which iodide of potassium was dissolved, M. Bremond (*Comptes Rendus*, 24 June, 1872, p. 1583) has been able to satisfy himself that this salt is absorbed by the skin. He finds that unless the skin has been well cleansed with soap before the vapour-bath, absorption does not take place below a temperature of 100.4 F.; but that if it has been thus cleansed, absorption takes place at temperatures varying from 93.2 to 96.8 F. The absorbed salt commences to be eliminated with the urine at about two hours after the bath; and elimination after a single bath altogether ceases within twenty-four hours, whatever may have been the quantity of salt in the vapour, or the temperature and duration of the bath. In cases, however, where ten or twelve vapour-baths have been taken, elimination continues during three or four days, and where twenty-five or thirty have been taken, it continues during ten or twelve days after the last bath.

ACTION OF VARIOUS SUBSTANCES ON THE NERVES OF THE SUBMAXILLARY GLANDS.—The well-known fact that dryness of the fauces results from the action of atropia, led Paul Keuchel (*Das Atropin und die Hemmungsnerven*) to examine the influence of this substance upon the secretory fibres of the chorda tympani. He discovered that these fibres are paralysed by atropia; and inferred that this paralysis is the result of a direct action upon certain inhibitory nerves. R. Heidenhain has lately repeated these experiments (*Centralblatt*, No. 21, 1872, p. 326; from *Pflüger's Archiv*, v. 40—47) on curarised dogs, by injecting into the jugular vein a dose of atropia sufficient to paralyse the cardiac filaments of the vagi. After this injection, excitation of the chorda tympani no longer caused secretion: nevertheless, there occurred an acceleration in the flow of venous blood through the gland, which differed in no essential respect from that which resulted before the administration of atropia. This observation proves that the secretion produced by excitation of the chorda tympani is entirely independent of any modification in the circulation of the gland, and, therefore, that totally different sets of nerve-fibres are concerned with the secretion and circulation of this gland. Indeed, notwithstanding the incapacity of the chorda tympani to excite secretion when it is acted upon by atropia, the sympathetic nerve still excited this secretion when it was irritated. It is, therefore, the extremities of the secretory fibres of the chorda tympani alone which are affected by atropia; and, accordingly the relation of these fibres with the secreting cells must be different from that of the fibres of the sympathetics. Heidenhain finds that the paralysis of the chorda tympani by atropia may be removed by physostigma. The latter substance has, besides, a special action on the gland; for if it be given to an animal after one of the chorda tympani nerves has been divided, there occurs a copious secretion on the side of the uncut nerve, and but little on the side where the nerve has been cut, shewing that the action is exerted on the central portion of these nerves. Nicotia and digatalin influence the secreting apparatus in the same way as physostigma; but large doses of the former substance paralyse the chorda tympani.

CHANGES UNDERGONE BY THE SECRETIONS UNDER THE INFLUENCE OF CERTAIN AGENTS THAT MODIFY THE BLOOD-GLOBULE.—In a thesis of great ability for the doctorate in Sciences of Paris (*Des modifications que subissent les sécrétions sous l'influence de quelques agents qui modifient le globule sanguin*, 1872) Mr Ritter, of Strasbourg, describes some important investigations made with oxygen, nitrous oxide, carbonic oxide, compounds of antimony and arsenic, phosphorus, and biliary acids. He specially examined the influence exerted by these substances upon the blood, urine, and general nutrition of the body. It is impossible to mention more than a few of the very interesting results he has obtained. Oxygen, inhaled in quantities of 25 or 30 litres, was found to augment the acidity of the urine, to diminish the nitrates, urea, and uric acid, and to considerably increase the ammoniacal salts. The urine voided after inhalation of oxygen, presented the singular character of very soon undergoing acid fermentation, and of remaining acid for a long time. Ritter states that only after two months does it become alkaline. Nitrous oxide, apparently a somewhat active poison for rabbits, pigeons, and frogs, always diminishes oxidation; and it cannot support life when mixed with an equal quantity of air. A saturated watery solution of this gas augments all the constituents of the urine—it produces, in short, true diuresis. Carbonic oxide likewise exerts a very decided influence on the urine, for it diminishes all the constituents of that fluid which are looked upon as the results of oxidation, and renders it albuminous. When tartar emetic, sulphide of antimony, arsenious acid or phosphorus is given to man, Ritter finds that large or toxic doses produce a more or less decided alteration of the blood, while small doses have a less energetic action. The blood-globule is deformed, and at the same time crystals of hæmoglobin make their appearance; the blood becomes anæmic, the albumen and globules diminish, the fibrin increases and the proportion of gas lessens; generally, the glucose augments; and the fatty bodies, including cholesterine, are always increased. These substances also modify the composition of the urine. They diminish the total quantity of nitrogen and urea; lessen the acidity and sometimes even cause it to become alkaline; and always augment the uric acid. Where the blood-globule is decidedly altered, and especially where crystals of hæmoglobin have appeared, the urine contains various abnormal constituents, and especially bile, albumen, and sometimes hæmoglobin. Finally, under the influence of these substances the formation and the deposit of fat is exaggerated, but only when they are given in moderate doses.

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ON THE ACTION OF INORGANIC SUBSTANCES WHEN INTRODUCED DIRECTLY INTO THE BLOOD.

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In the present paper I propose to bring forward some experiments showing the action of the salts of Soda, Lithia, Cæsium, Rubidium, Thalium, and Silver, when introduced directly into the blood. For the manner in which the experiments were performed, I would refer to my communication in the May Number of this *Journal*, 1870.

Exp. 1. A dog, weight about 18lbs. Pressure in the arteries 6 to 7 in. 15 grs. of nitrate of soda, in half an ounce of warm water, was injected into the jugular. In 7″ the pressure in the arteries diminished 2 in., but in a few seconds regained its former level. Respiratory movements rather deeper. After 10′ the animal seemed about the same as before the injection. 10′, pressure 6 to 7 in.: inject 30 grs.; 8″, pressure in the arteries rapidly falling; respiratory movements almost suspended. 30″, pressure 2 in., although the heart is beating strongly. 45″, pressure in the arteries increasing. 1′ 15″, pressure 6 to 7 in., respiration again becoming regular, and the animal apparently not much affected. 10′, pressure 5 or 6 in.; inject 40 grs. In 10″, rapid diminution of pressure. 30″, pressure 1 in., violent spasm with opisthotonos. 35″, spasm gradually relaxed, but no respiratory movement for more than two minutes; respiration was again established, and the animal became conscious. 2′ 30″, pressure 4 in., respiration very quick.

3′, frothy fluid escaping from the air-passages. 5′, animal died. On opening the thorax the heart was found beating, and retained its irritability for some minutes: the right cavities much distended with blood: left cavities contained a smaller quantity of partially arterialized blood. The lungs were œdematous and red; and all the air-passages were filled with a frothy fluid.

Injected in larger doses into the veins the salts of soda completely and suddenly stop the passage of the blood through the lungs, causing violent opisthotonos from accumulation of blood in the venous system, and thus producing immediate death[1].

Exp. 2. Dog, weight 30lbs. Pressure 5 to 5½in. Inject 60grs. of nitrate of soda into axillary artery. Immediate expression of pain. 10″, general spasm with opisthotonos. 16″ after the injection, pressure 14in., action of the heart unaffected; on the spasm relaxing, the animal was dead: pressure falling slowly; heart's action regular. 3′, pressure 6in. 5′, pressure 3in., heart's action quick and weak. On opening the thorax, the heart was found beating rhythmically; both cavities full of dark blood; lungs slightly œdematous; blood coagulated. The nitrate is the most poisonous of the salts of soda with which I have experimented. Much larger quantities of the sulphate or the carbonate can be injected without producing death.

Salts of Lithia.

Exp. 3. A rabbit; weight about 3½lbs. Pressure 4·2 to 4·5in. Inject 3grs. of sulphate of lithia into the jugular; no effect. 5′, inject 3grs.; no effect. 4′, inject 5grs. 4″, pressure falling. 10″, pressure 2½in., respiration quickened. 30″, pressure 4in., inject 7grs. 10″, pressure 2in., animal not suffering; inject 8grs. 4″, pressure falling. 10″, pressure 1½in. 45″, pressure 3½in., heart beating regularly, respiration quickened. About 4″ after the last three injections there is a well marked single jerking inspiration; pressure 3½in., inject 12grs. 4″,

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[1] There can be no doubt but that this opisthotonos is the result of the increased pressure of the blood in the venous system, forasmuch as it is prevented or relieved by dividing the jugular. Direct experiment shows that on the arrest of the pulmonary circulation the pressure in the venous system becomes equal to an inch and a half of mercury.

violent struggles. 10″, opisthotonos, which relaxed in about 1′; animal dead; pressure not observed. On opening the thorax, the heart was found beating rhythmically; right cavities distended with blood not very dark; left cavities contained small quantity of blood only partially arterialized; lungs red and œdematous; frothy fluid in the bronchial tubes.

Exp. 4. A rabbit; pressure 4 to 4·2in. Inject 7grs. of sulphate of lithia in ʒij water into carotid. 3″, pressure rising, expression of pain. 10″, pressure 6in. 20″, pressure 5in. The pressure gradually fell to 4in., respiratory movements quickened, no marked effect. 7′, pressure 4·3 to 4·5in., inject 6grs. 3″, pressure rising. 10″, pressure 6in. 30″, pressure 4.8 to 5in. 5′, pressure 5 to 5·2in., inject 7grs. 5″, increase in pressure. 10″, pressure 6in.; general spasm; heart's action slow and irregular. 1′, pressure 4in. 1·30′, pressure 2in.; respiration very rapid; conjunctiva sensible, but no expression of pain or reflex movements on pinching the tail. 5′, pressure 2 to 2½in., inject 8grs. 10″, pressure 3 to 3½in.; general spasm; respiration arrested; animal dead. On opening the thorax, both cavities of the heart and the veins and arteries were full of blood, the blood in the left cavities and arteries partially arterialized. On taking out the blood, heart contracted for some minutes. Lungs œdematous; frothy secretion in the bronchial tubes and tracheæ. Blood coagulated firmly; the corpuscles much crenated; molecular movements well marked for many hours after death.

Salts of Thalium.

Exp. 5. Rabbit: pressure 5½ to 6in. Inject 1½grs. of sulphate of Thalium, in ʒi. water into the jugular. 5″, pressure diminishing. 12″, pressure 2in. 30″, pressure 6½in., heart's action quicker; respiration accelerated; animal appears not to suffer. 5′, pressure 5½in.; inject 2grs. 6″, pressure falling. 12″, pressure 2in.; respiration irregular, intermittent for 2′ 30″, when the animal died, the pressure gradually falling. On opening the thorax the heart was found beating rhythmically: right cavities much distended with dark blood; left cavities contained a small quantity of bright scarlet blood.

Exp. 6. Rabbit: pressure 4·8 to 5 in. Inject 1 gr. sulphate of thalium into the carotid; no effect. Inject 2 grs. 7″, pressure falling. 10″, 3½ to 4 in. 30″, pressure rising. 40″, pressure 6 in. 2′, pressure 5 in.; animal apparently not affected. 5′, pressure 5 to 5½ in., inject 3 grs.; breathing quickened. 12″, pressure falling. 25″, pressure 3 to 3½ in. 2′, pressure 5 in.; respiration natural. 7′, pressure 5 in., inject 4½ grs. 3″, respiration quickened, slight struggle. 10″, pressure falling. 20″, pressure 2½ to 3 in. 45″, pressure 4 in.; respiration natural; animal apparently not affected. 5′, pressure 4½ to 5 in., inject 5 grs.; respiration immediately quickened. 7″, pressure falling. 20″, pressure 2 in., heart beating regularly. 40″, pressure rising. 1′ 30″, pressure 3 to 3·2 in.; animal sensible, apparently not much affected. 6′, pressure 4 in., inject 12 grs.; the immediate effect on the circulation could not be ascertained, owing to the struggles of the animal. 30″, pressure 2 in. 45″, pressure 4 in. 1′ 30″, respiration stopped; pressure 3 in. On opening the thorax, the heart was found beating rhythmically; right cavities distended; left cavities contained small quantities of arterialized blood; lungs red, but contracted.

Salts of Rubidium.

Exp. 7. Rabbit: pressure 5 in. Inject 2 grs. of chloride of rubidium into the jugular. 5″, pressure falling. 10″, pressure 1½ in. 1′ 30″, pressure 4·8 to 5 in.; the respiration quickened. 8′, pressure 5 in. Inject 2 grs. 4″, pressure falling. 15″, pressure 2½ in.; spasm; respiration stopped one minute after the injection. On opening the thorax, heart contracting rhythmically: right cavities distended with dark blood: left contained a small quantity of scarlet blood. Lungs scarlet. Blood coagulated.

Exp. 8. Rabbit: pressure 4½ to 5 in. Inject 2 grs. of chloride of rubidium into the left carotid. 7″, pressure less. 15″, pressure 2½ in.; slight spasm. 25″, pressure rising. 1′, pressure 4½ in.; heart's action regular; respiration quickened. 5′, pressure 4 in.; inject 3 grs. 7″, pressure less. 12″, pressure 2½ in. 45″, pressure 4 in.; heart's action regular, but oscillations slight. Owing to an accident the hæmodynamometer could no longer be used. 7′, inject 6grs. 10″, tonic spasm; respiration suspended for 15″, then irregular for 2′; sensibility apparently unimpaired. 3′ respiration regular, but very rapid. 5′, inject 10grs. 10″, respiration suspended. 45″, respiration commenced and continued irregularly for about 1′; animal then died. On opening the thorax the heart was beating rhythmically; right cavities much distended; left contained a small quantity of scarlet blood.

Salts of Cæsium.

Exp. 9. Rabbit: pressure 4 to 4·2in. Inject 1½gr. of chloride of cæsium into the jugular. 5″, pressure falling slightly. 15″, pressure 3½ to 4in.; respiration quicker. 5′, pressure 3½ in., inject 3 grs. 5″, pressure falling. 7″, respiration quickened. 10″, pressure 2in. 45″, pressure 3in.; respiration more natural; animal sensible. 5′, pressure 3½in. Inject 4½grs. 5″, pressure less; 7″, general spasm; 10″, pressure 1in., animal dead. On opening the thorax the heart was found contracting rhythmically, and continued contracting 12′ after death: right cavities distended: left cavities contained a small quantity of scarlet blood.

Exp. 10. Rabbit: pressure 4 to 4½in. Inject 4grs. of chloride of cæsium into the carotid. 3″, general spasm; respiration suspended. 35″, respiration renewed, regular but quick; posterior extremities and trunk stiff, as in rigor mortis. 1′, cornea insensible. 4′, respiration natural; lids close about 2″ after irritating cornea; animal lies quite still, limbs stretched out as in a state of rigor, no sign of consciousness, but reflex movements on pinching the tail. 10′, signs of returning consciousness, respiration regular, 15 in a minute. 12′, inject 4grs., no marked effect: respiration 15 in a minute, principally diaphragmatic. 5′, inject 5grs. 3″, violent spasm lasting about 10″, animal dead. On opening the thorax the heart was beating rhythmically, and continued contracting for 10′: both cavities contained blood; that in the left rather brighter than in the right but still dark. (Note in consequence of the hæmodynamometer becoming obstructed, the pressure could not be observed.)

Salts of Silver.

Exp. 11. Dog: weight 15lbs. Pressure 5 or 6in. Inject 3grs. of nitrate of silver into the jugular. 7″, pressure less. 30″, pressure 3in. 40″, pressure rising. 1′ 20″, pressure 8 to 9in.; respiration quicker. 2′, pressure 3in. 5′, pressure 2½in.; heart's action slower, 58; breathing rapid, 48. 7′, frothy fluid escaping from the mouth; pressure 2in. 12′, respiration stopped; the heart still felt beating through the chest-walls, although causing no oscillation in the mercury. On opening the thorax the heart was contracting rhythmically, and continued contracting for 10′; the right auricle contracted spontaneously half an hour after the thorax had been opened. The blood both in the right and left cavities was dark and viscid; it did not coagulate. The lungs were red, partially hepatised; the air-passages were full of a frothy secretion.

Exp. 12. Dog: weight 15lbs.; pressure 6 to 6½in. Inject 1gr. of acetate of silver into the axillary artery. 4″, pressure rising. 8″, pressure 12in. 20″, pressure 10in. 1′, pressure 9in. 3′, pressure 7½ to 8in.; respiration quickened. 5′, pressure 7 to 7½in., inject 2gr. The immediate effect on the pressure was not observed, owing to the tubes being obstructed. General spasm and arrest of respiration. At 1′ to 1′ 30″, pressure 10in.; heart slow, 35 in a minute. 3′, respiration again commenced, lasted irregularly for two minutes, and then stopped: animal dead, five minutes after the injection pressure in the arteries gradually fell. On opening the thorax the heart was beating rhythmically; its contractions continued for 8′; right cavities distended; left cavities moderately full of dark blood which coagulated very imperfectly. Lungs hepatized, red, and some spots of ecchymoses: frothy secretion in bronchial tubes: twitchings in the voluntary muscles 8 minutes after death.

The substances, the action of which has been described in the above experiments, form an interesting group, possessing, as they all do, certain isomorphous relations, and yet not so closely agreeing in all their chemico-molecular properties as some other isomorphous groups. An analogous remark will apply to their physiological reactions. When introduced directly into the blood they all have certain well marked resemblances; but still there are differences which serve to distinguish some of them in their reactions on the different organs. Amongst the most marked reactions they produce is the manner in which they act on the lungs. Without exception they are all lung-poisons. They all kill when injected into the veins, either by directly arresting the pulmonary circulation, or by causing changes in the lung-tissue which rapidly prevent the aëration of the blood. They also all agree in another important respect. Some of them, notwithstanding the marked changes they cause in the blood, do not at all diminish the irritability of the heart. In fact I believe they all increase the irritability of the heart muscles; so that these continue to contract longer without the stimulus of arterialized blood. There is another property which they all seem to possess, with the exception of cæsium; and that is, that they exert no direct effect on the functions of the nervous system. In striking contrast to their action in arresting the passage of the blood through the pulmonary capillaries is the facility with which they all, with the exception of silver, pass through the systemic capillaries, unless introduced into the arteries in large quantities. Nothing can more strikingly show the want of action of these substances on the nervous system, and on the systemic circulation, than the fact that they can be introduced in much larger quantities into the arteries than into the veins without proving fatal. With the salts of thalium, for example, three and a half grains, when injected into a vein, will instantly kill by arresting the pulmonary circulation; whilst six times the quantity can be injected into the arteries without producing any marked symptoms. They pass over the heart through the nervous tissue, and find their way through the systemic capillaries without apparently causing any marked change in these organs; and it is only when injected into the arteries, in quantities large enough for them to reach the lungs in a sufficiently concentrated state there to give rise to these well marked effects, that they kill. These properties are found in all the more strictly isomorphous members of the group. The only exceptions met with are in the salts of cæsium and silver; the latter evidently an outlying member of the group. The former of these salts exerts a decided action on the nervous system when introduced into the arteries, and a small quantity of a salt of silver, in the arterial blood, causes obstruction to its passage through the systemic capillaries.

As to the mechanism of the arrest of the pulmonary circulation, two explanations are admissible. The pressure of these substances in the blood gives rise, either directly, or through reflex action, to contraction of the smaller pulmonary arteries; or they arrest the passage of the blood through the capillaries by the changes they make in the shape of the blood corpuscles. I have found that all these substances, so far as examined, produce changes in the shape of the blood corpuscles. The following appearances were observed in a microscopical examination of the blood six hours after death, from a rabbit that had been killed by cæsium (see Exp. 9). Blood from right side of the heart coagulated, but not much contracted: blood from left side perfectly fluid. In the venous blood not a natural coloured corpuscle was found. About one-third of the corpuscles were colourless, and adhered to the slide. The others had all lost their natural discoid shape. They were thickened, and nearly all crenated generally with six indentations. Where they still retained a circular outline, the border seemed thickened; as they rolled over, they were all found to be curved; the colouring matter was collected in points or around the thickened border. In the blood from the left cavities not a crenated corpuscle could be found. They all retained their circular outline, but were contracted and thickened. The size of the crenated corpuscles in the venous blood was 5·5 $^{\text{mmm}}$, of the round corpuscles 6·7 $^{\text{mmm}}$. In this instance it would seem as if the lungs had acted as a filter by which the roughened corpuscles were retained; as there must have been many roughened corpuscles in the blood for some time before the last injection. This is the most marked example I have met with of the absence of roughened corpuscles in the blood from the left cavities of the heart. But they are always in a smaller proportion than in the venous blood. In none of the specimens of blood examined after the injection of any one of these salts have I seen the corpuscles agglutinated in rouleaux. The molecular movements are very active many hours after death. Should this mechanical explanation of the arrest of the pulmonary circulation be correct, we are still to consider how it is that many of these substances when injected into the arteries find their way through the systemic capillaries without causing obstruction, unless in large doses. This point however, together with a more detailed account of the changes caused in the lung-tissue, I must leave for a future communication.

ERRATA IN PRECEDING PAPER, Vol. VI.

Page 95, line 13, from top, *for* 2 or 2·2 inches, *read* 2 to 2·2 inches.

Line 9 from bottom, *for* respiration stopped; in 40″ hearts—*read* respiration stopped in 40″; hearts.

Page 96, lines 3 and 4, *for* down to 3·5, respiration suspended; for 30″ animal sensible—*read* down to 3·5; respiration suspended for 30″; animal sensible.

Line 6, *for* arrested; at 2′, *read* arrested at 2′;

Line 8, *for* suspended; 1′·30″—*read* suspended 1′·30″;

Page 97, line 9, from bottom, *for* quick; but regular respiration—*read* quick but regular; respiration.

Page 100, line 4, *for* overdisturbed state, *read* overdistended state.

ON THE PHYSICAL NATURE OF THE COAGULATION OF THE BLOOD.—By ALFRED HUTCHISON SMEE, F.C.S., F.S.S.

Read at a Meeting of the Royal Society.

THE cause of the coagulation of blood fibrine has long been a vexed question among physiologists. In bringing this subject under the notice of the Royal Society it is my intention, first, briefly to review the various theories which have been held at different times, and, then, to state those views on coagulation which have been enforced upon my mind by direct experiment, and also by the behaviour of colloidal substances analogons to fibrine.

Hunter, the great upholder of vital force, thought that coagulation of the blood was an act of life, and was analogous, to some extent, to the contraction of a muscular fibre. Hewson, a contemporary, in opposition to Hunter's views, noticed that blood could be kept fluid for months by addition of certain neutral salts. This experiment has been urged as conclusive evidence against Hunter's theory of coagulation; for it is impossible to conceive that vital power could last for such a length of time. Gulliver found that blood remained fluid for one year on the addition of nitre, yet still retained its power of coagulation on the addition of water.

Coagulation was held by other physiologists to depend upon the stasis of the blood in the vessels; and they pointed to the coagulum at the point of ligature in an artery which had been tied as the result of the stasis.

Again, exposure to air was stated to be necessary for the formation of a coagulum; and it was supposed that something, probably of a gaseous nature, was given off from the blood at the time of coagulation.

The evolution of carbonic acid from the blood was considered to be the cause. Dr Richardson considered that fibrine was held in solution by free ammonia which escaped from the blood on exposure, when the fibrine began to coagulate.

In an experiment which I related in my paper on the artificial formation of fibrine from albumen, I demonstrated that ammonia, in quantities greater than could ever be found in the blood of the living body, might be added to albumen; nevertheless when this albumen was submitted to the action of oxygen at temperature of 98° fibrine formed, although it was afterwards slowly dissolved.

Lester pointed out in one of his experiments, that, on carefully neutralizing the blood with acetic acid no alteration was made in the power of its coagulation. Coagulation however was observed to take place more rapidly *in vacuo*, giving some justification to the views of those who hold to the theory that the blood exhales from itself some volatile principle at the time of coagulation.

Heat likewise is said to favour, and cold just above the freezing point to retard, coagulation.

In asphixiated animals coagulation was found to be retarded. This fact was regarded as evidence that carbonic acid kept the blood fluid.

Astley Cooper and Thacknot thought that the blood-vessels, exerted a specific influence in actively preventing the coagulation of the fibrine in the blood. Brücke supported this view. He found that the blood of a turtle injected into an empty heart remained fluid for many hours, whilst some of the same blood exposed in an open vessel coagulated in a few minutes. Lester found that, on inserting a tube into the circulating system, fibrine, in a short time, separated from the blood, the coagulum coating the internal surface of the tube; but that, after a time, fibrine ceased to separate from the blood. This was a case of blood coagulating in a sealed vessel and disposed, to my mind, of the exhalation theory of coagulation. Morrant Baker, in the 1st Vol. of the St Bartholomew Hospital Reports, remarks that the blood, in blood tumours, remained fluid, and that the fibrine in most cases had separated from the liquor sanguinis. He further remarked that the internal surface of the tumour was coated with a coagulum which had apparently undergone organization, and was, in tumours of old duration, hard, and like fibrous tissue. The specific gravity of this blood had fallen from 1052 (normal blood) to 1020. Sometimes, however, a portion of blood coagulated when the tumour was opened. He thinks this is due to bleeding from the small vessels which have been punctured by the incision, the fresh blood mixing with the blood of the tumour, and a second coagulation takes place. I think this phenomena may be explained by Lester's tube experiment, where he shews that when blood is first effused, or passed into or through a tube which had not previously been coated with blood fibrine, the fibrine separates into a coagulum, this coagulum then undergoes organization into fibrous tissue; but, if on a second hæmorrhage taking place into a blood tumour, or if more blood is passed through the fibrine coated tube, the fibrine will not separate from the liquor sanguinis. When a needle or wire is inserted into a blood-vessel whilst the blood is circulating it acts as a foreign body, and it soon gets coated with a fibrinous deposit: upon this principle is founded a treatment for the cure of aneurism.

Lester has demonstrated that the blood will remain fluid in the jugular vein from 24 to 48 hours after death, provided the vein has been tied just before or just after death, but when the blood is turned out coagulation immediately takes place. Buchanan has shewn that the fluid from a hydrocele yielded a coagulum on the addition of blood serum although each fluid, without the addition of the other, might be kept separate for any length of time without coagulation taking place. Schmidt also held the same view, but considered that it required a fibro-plastic substance of the nature of globulin to combine with another substance which he termed fibrogen.

Lionel Beale has studied the phenomenon of coagulation under a magnifying power of upwards of 2000 diameters ($\frac{1}{50}$ inch). The first change he noticed was a film-like appearance in the liquor sanguinis, especially in the track of the red corpuscles as they slowly traversed the field. This film-like appearance was succeeded by delicate threads apparently corresponding with the track of the blood-cells, these lines gradually increased in density and refractive power.

He thinks that this coagulable matter exists, in the first instance, as a diffused plasma probably formed from the white cells which, gradually separating from the serum, contracts, acquires density, and thus becomes visible under the microscope.

During coagulation the red cells become stellate, refract more highly, lose diameter and fluid; at which time probably globuline escapes.

Lastly, when blood is stirred up with twigs coagulation proceeds more rapidly.

Having thus briefly reviewed the principal theories held by physiologists, I now venture to submit that view which, in my opinion, best accords with all observed facts.

From a careful review of all the circumstances of the case we may fairly consider that the coagulation of the blood takes place in obedience to a purely physical law, namely, the power of soluble colloid matter, whether organic or inorganic, to pectize, or in other words, spontaneously to coagulate. In order that I may illustrate this view of the coagulation of blood, I must ask the Fellows of the Society to travel with me into the paths of inorganic chemistry, especially calling attention to Graham's experiments on colloid matter published in his paper "on liquid diffusion applied to analysis."

The act of pectization of a colloid body may be regarded as the equivalent of the act of crystallization of a crystalloid body.

Take for instance a solution supersaturated with sulphate of soda, it will remain fluid for days. Stir it, or even drop a particle of dust into the fluid, it will instantly begin to crystallize.

In this case we observe a perfect analogy between the action of a particle of dust which determines the act of crystallization in this solution and that of the wires or twigs which, when applied to blood, produce a rapid formation of a coagulum. No one can say that this crystallization of the sulphate of soda was an act of vitality.

Graham has shewn that the essential characters of all colloids are to form a jelly and not to dialyse. This jelly he regards as the pectous or insoluble state; whilst the soluble state of a colloid he regards as the peptous. An inorganic colloid in the pectous condition is a vitreous mass, homogeneous and perfectly structureless, in which state it apparently remains an indefinite time, gradually losing water and becoming more and more dense, and probably after the lapse of years it is capable of undergoing transformation into a more or less crystalline state. In nature the structureless flint may be found gradually being converted into the crystalline. When an organic colloid assumes the pectous condition it contracts and crushes up into fibres. This is the case with fibrine, albumen and gluten.

Graham has also shewn that all organic colloid substances have high chemical equivalents, and are at the same time chemically inert in the ordinary sense, but possess a compensating activity from other physical properties. Crystalloid bodies appear to shut out external impressions, whilst colloids possess properties, to use Graham's own words, which enable them to become the medium of diffusion like water itself. Another characteristic quality of colloids is their constant mutability. Their existence is a continual change. A fluid colloid may assume a pectous modification, and often passes, without any visible external influence, or even of internal change, from the first (the fluid) to the second (the pectous) condition. Colloidal substances, such as gelatine, which gelatinize, but still retain their power, again become fluid by heat and are soluble in water, cannot be regarded as assuming the pectous condition, but the gelatinous.

Graham has demonstrated that when a soluble colloid has assumed the pectous or coagulated condition it cannot again *per se* become fluid. In the case of certain colloids, however (silicic acid, for instance), the addition of a small quantity of an alkali to the jelly causes it to again liquefy. If the fluid containing silicic acid *plus* the alkali is placed upon a dialyser, the alkaline salt is removed, leaving the silicic acid in a pure and soluble state, in which condition it will remain for some time, when it will again assume the pectous state. The addition of the alkali, however, appears to have had no chemical action on the silicic acid jelly, but only changed its physical condition from the pectous to the peptous or fluid state. On the other hand, the act of gelatinization may be repeated *ad infinitum*, as the gelatine may be melted over and over again.

I must now direct attention to Graham's experiments on the behaviour of hydrated silicic acid, and to the analogous physical behaviour of film. Graham has shewn that hydrated silicic acid, in a state of great purity, can be obtained and held in solution, but cannot be preserved in that state for any length of time. It will remain fluid for days, and even for a longer period, if it is in a sealed tube; but it will ultimately spontaneously coagulate and become insoluble. A concentrated (14 per cent.) solution assumes the pectous condition in a few hours. A 5 per cent. solution may be kept for some days. A 2 per cent. solution will keep two or three months; and a 1 per cent. will remain fluid even after two years.

The addition of solid matter in the state of powder to liquid silicic acid greatly favours the act of pectization, the solid matters apparently acting as a nucleus, like the dust in sulphate of soda in solution, and set up crystallization.

The addition of one 10,000th part of an alkaline carbonate to fluid silicic acid causes it to immediately pectize. The silicates of the alkalies are themselves soluble in water; but no one would assert that the addition of an alkaline carbonate could have any other effect on silicic acid than that of a foreign body setting up a new physical condition, for no chemical action can possibly have taken place during the transition of the silicic acid from the fluid to the pectous state. Acids and other neutral salts likewise cause coagulation. Caustic ammonia, however, has no action on fluid silicic acid. Alumina likewise has the power of existing in the fluid and pectous state without the intervention of an acid; but soluable alumina is one of the most difficult substances to prepare owing to its unstable nature in the fluid state. A vessel washed out with ordinary water (which contains a trace of sulphate of potash) is sufficient to cause it at once to coagulate. The addition of sulphate of potash, in the one case, or of an alkaline carbonate, in the other, cannot be said to have effected any chemical change in these colloids to cause them to pectize. I believe that neutral salts added to the fluid silicic acid act in a similar manner to the handful of twigs used for stirring up blood, as they act simply as foreign bodies.

Soluble peroxide of iron is more interesting to the physiologist than either soluble silicic or albumina, on account of iron being one of the constituents of the blood; and it is more than probable that the iron in the red blood corpuscles is in a fluid state. Graham remarks that soluble peroxide of iron remains fluid for 20 days, provided it is in a weak solution and kept in sealed glass tubes, when it will suddenly spontaneously pectize without any apparent cause. Water containing 1 per cent. of hydrated peroxide of iron has the deep red colour of venous blood. This solution can be concentrated to a certain point, when it will suddenly pectize. The coagulum is a deep red coloured jelly resembling blood-clot. Graham remarks that the feeble circumstances which suffice to produce this change is highly suggestive of blood.

The following experiments which I have made upon fresh-drawn blood illustrate the manner in which fibrine pectizes in animal fluids. These experiments clearly demonstrate that the act of coagulation takes place in accordance with purely physical law.

On the addition of an equal quantity of a solution of sulphate of soda to fresh-drawn blood coagulation will not take place, and the blood will remain fluid an indefinite time. The blood-cells however will gradually subside, leaving the liquor sanguinis containing the uncoagulated fibrine bright and clear. If some of this liquor sanguinis is placed in a dyalyser and then the dyalyser placed in distilled water, in the course of a few hours the sulphate of soda will dyalyse out of the liquor sanguinis, and a thin gelatinous film of fibrine will be formed at first, in direct contact with the parchment paper of the dyalyser. This film of fibrine will gradually extend and become thicker as the sulphate of soda slowly dyalyses out of the solution; and after the lapse of 10 or 12 hours the whole will have become one uniform structureless clot. This clot will, after some days, contract, squeeze out the liquor sanguinis, lose its structureless appearance, and crush up into fibres.

If a second quantity of the liquor sanguinis is placed on the dyalyser which has been previously coated with fibrine jelly, the second quantity will require a greater length of time for coagulation to begin. This is especially the case if a cup-shaped depression has been made in the fibrine jelly for the second quantity of the liquor sanguinis. When the solution of sulphate of soda is added to the liquor sanguinis in excess, the time of coagulation is delayed in the direct ratio to the quantity of the sulphate of soda added to fresh-drawn blood.

If the fluid which is placed upon the dyalyser contains not more than one part of the liquor sanguinis to 30 pints of the sulphate solution no pectization will take place, even after the sulphate has been removed by long-continued dyalysing; and probably the fibrine remains fluid upon the dyalyser sufficiently long to get oxydized, and converted into some other substance. Upon this point I purpose making further investigation. The fibrine jelly formed by dyalysing is dissolved slowly in caustic potash, leaving behind a small quantity of hexagonal crystals which are soluble in acetic acid. I have placed fibrine jelly which has been redissolved in potash upon a dyalyser to remove the alkaline salt, but I have failed in every instance to get the film a second time to pectize.

I have observed a very curious property in fibrine jelly (which has been made from a dilute solution) of breaking up and becoming again fluid, and passing through the blotting paper filter used to separate the liquor sanguinis from the fibrine jelly. I can find no satisfactory explanation of this remarkable change, unless we accept the view that very minute causes are sufficient to determine the physical condition of colloid substances.

Dr Goodman has noticed that albumen suspended in a ropy condition in cold water, coagulated after some time, became white, dense, insoluble, and finally fibrous. This change he regarded as evidence of the formation of fibrine from albumen. I have frequently repeated the experiment. I believe that no new substance is formed out of the albumen by this method, which I believe has only changed its physical condition from having its salts removed by dyalysis, which causes the albumen to change from the peptous to the pectous state.

Having brought under the notice of the Society some of the principal characteristics of colloid, I will now proceed to a comparison between the behaviour, physically, of the inorganic colloid silica with that of the organic fibrine.

In every essential point it will at once be recognized that these two dissimilar substances agree, and, at the same time, that there is no circumstance during the act of coagulation which cannot be explained by physical law.

The analogy between fibrine and silica in their physical behaviour will be best observed by comparing their properties together. 1st. Fibrine and silica colloidal substances are known to exist in the fluid as well as in the coagulated condition. 2nd. When either fibrine or silicic acid assumes the pectous state it is incapable of being *per se* redissolved, so as again to be able to spontaneously pectize. The existence of both these substances is a continual metastases: fibrine is a typical instance of this metastases. 3rd. All colloids in the fluid condition, whether of organic or inorganic origin, after an interval of time, longer or shorter according to their specific characters, spontaneously coagulate. 4th. This coagulation takes place without the intervention of any chemical agent which is capable of producing a change in that colloid. 5th. The condition of neutral salts to inorganic colloids in a fluid state (just as the falling of a speck of dust into the supersaturated solution of sulphate of soda favours crystallization) favours the coagulation of those colloids. The neutral salts in these cases must be regarded as foreign bodies. Possibly the white blood-cells, altered in their physical condition by exposure to air, become as foreign bodies to the blood, and have a similar influence as twigs and rods used ordinarily to defibrinate blood.

Lastly, the capacity of all colloids to remain in the fluid condition is greatly promoted. 1st. By the weakness of the solution (less than 10 per cent.); 2nd. By being contained in sealed vessels.

The time required by a fluid colloid to pectize apparently depends upon its molecular equivalent.

The fluid condition appears to be less stable in colloids with high molecular equivalents, and the act of pectizing takes place more rapidly and with less apparent cause, and apparently in direct ratio to the molecular equivalent of the colloid. Consequently soluble peroxide of iron pectizes sooner than alumina, and alumina more rapidly than silica. Therefore fibrine, with a molecular equivalent vastly higher than either of these colloids, might be expected to coagulate almost immediately.

Occasionally masses of natural silica containing fluid are found in nature, of which I myself possess a remarkably fine specimen. These appear to me to have a great resemblance in their formation to that of the blood-tumours described by Morrant Baker. The enclosed fluid may be analogous to that in Lester's experiment where fibrine ceased to coagulate or separate when passed through a tube which had been previously coated with blood-fibrine.

In the case of the natural stone what has taken place? 1st. Silica has been deposited. 2nd. Coagulation has taken place; and the coagulum has contracted and formed a cavity in its inner surface. 3rd. The addition of more (fluid) silica has taken place; and the external coagulum has been transformed, passing, after the lapse of time, from the vitreous to the crystallized state.

The second quantity of the fluid silica has coagulated; but it has coagulated in the gelatinous form, squeezing out the remaining water.

This recalls to our minds what takes place in blood-tumours, 1st. Blood is effused; 2nd. The fibrine is coagulated; 3rd. The coagulum contracts and becomes organized into the dense hard fibrous margin. If a second effusion of blood now takes place the blood will remain fluid, and will remain so for a considerable length of time; but at last the fibrine will coagulate squeezing the liquor sanguinis.

To my mind the analogy between the formation of the fibrine in a blood-tumour and the deposition of silicic acid in certain natural stones is complete.

The above considerations of the causes of the coagulation of blood-fibrine may be briefly summed up. 1st. That the coagulation of fibrine is a physical act, and cannot be considered to be in any way identified with a vital property such as the contraction of muscular fibre. 2nd. The coagulation of fibrine depends upon and is regulated by the same laws which cause all soluble colloid substances, whether organic or inorganic to become pectorous. 3rd. That the soluble or fluid form of fibrine ought to be regarded as its allotropic form; and, as in the case of its colloidal analogue, silicic acid, its presence in the blood in the fluid condition depends upon the physical conditions under which fibrine is found in the living body.

ON THE LAW WHICH REGULATES THE FREQUENCY OF THE PULSE. By A. H. GARROD, B.A. *Cantab.*

THE paucity of mechanical theories to explain the frequency of the pulse, probably arises from the very general assumption, that in all cases when the rapidity of the heart's beat is caused to vary, the action of nerves, with special powers of retarding or quickening it, is brought into play; and the relation of heart power to work to be performed has not been introduced into the problem.

The theory of energy has of late spread so far and wide the necessity for finding in all cases where work is done, a sufficient source for the production of that work, in one form or other, that a vague statement to the effect that heart frequency depends solely on nerve action, is far from sufficient for the requirements of physiologists. It is now necessary to shew that with different amounts of work to be performed in the circulation, different supplies of nutrient substance must be presented to the motor organ, just as in the steam-engine the amount of fuel must be varied according to the work required from the machine.

When the microscope revealed the existence of a well-marked muscular coat to the smaller systemic arteries, it became evident that the different diameters of those vessels, consequent on the degrees of contraction of their walls, varied the amount of force necessary to propel the blood through them; and these variations have been considerably studied of late. Dr Marey of Paris, the introducer of the sphygmograph, has, in his most scientific treatise *On the Circulation of the Blood*[1], strongly drawn attention to this subject, and he has worked out a theory respecting the law regulating the frequency of the pulse, which is based mainly on the variations in arterial resistance.

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[1] *Physiologie Médicale de la Circulation du Sang.* Paris, 1863.

This theory of Marey's it will be necessary to recapitulate here, and to examine the facts on which it rests. The following is the law in the two forms in which he gives it.

1. "The heart beats so much the more frequently, as it experiences less difficulty in emptying itself."

2. "The frequency of the pulse varies inversely as the arterial tension."

As reasons for the accuracy of this law are given:—

1st. The analogy of other intermittent muscular movements, as the following—A man can walk a certain distance quicker, the less he is loaded. Or this—The hand can be moved alternately backwards and forwards more quickly in air than in the more resisting fluid, water.

2nd. The pressure can be made to change by variations in the amount of blood in circulation, and by modifications in the degree of arterial or capillary resistance, both of which vary the pulse-rate in the manner required by the theory.

To prove the effects of different amounts of blood in circulation, the experiments of Hales are quoted, in which he found that loss of blood increased the frequency of the pulse.

To prove the effects of varied arterial or capillary resistance many satisfactory and original results are referred to, among them, the effect of compressing the abdominal aorta, or the femorals, which retards the pulse; the effects of cold baths, according to Drs Bence Jones and Dickinson, when the pulse was greatly reduced in frequency; the quickened pulse following successive additions of warm clothing over the body is also proved.

From these latter results it is clear that Marey assumes that by varying the capillary resistance the blood-pressure is also varied at the same time, but this assumption is not necessarily true in a circulation that is maintained by a pulsating motor organ, whose rate is variable, as can be easily shewn by an analogy from electricity, which is a useful one in many ways to students of the circulation, and is quite worth being worked out by each. It is this—Suppose a battery connected, through a break-and-make key, to a long uniform insulated line or telegraph cable, insulated at the other end, and connected with a static galvanometer.

First connect the two parts by the key and thereby charge the line, and then break connection; upon this the charge will fall in tension slowly, and this fall may be observed on the galvanometer; when the tension has fallen one half, reconnect and break again. It is evident that if this process be repeated a definite current is maintained between the cable and the surrounding bodies to which it leaks. If the line be now halved in length, whereby the resistance is doubled, and again insulated at the free end, it is evident that by again breaking and making contact as before, when the tension is halved, the maximum tension will not be changed. So with the circulation, if the resistance in the arterial peripheral vessel is varied and the length of the pulsation depends on the time of fall in tension only, the pressure does not vary, if the vascular capacity is constant.

It is thus seen that the blood-pressure need not depend on the arterial resistance, but if the pressure does not vary, the pulse-rate must do so.

A desire to arrive at the genuine value of this theory of Marey's led me to make experiments similar to his own, as to the accuracy of his fundamental facts. My observations were divided into two series, to find,—

1st. Whether the pulse-rate was related to the capillary resistance.

2nd. Whether the pulse-rate depended on the pressure of the blood in the arteries.

These points will be considered separately.

1st. *The relation of the pulse-rate to the arterial resistance.*

The effect of exposing the surface of the body to the influence of different temperatures, whereby, as it has been my endeavour to prove elsewhere[1], variations in the calibre of the cutaneous vessels are produced, was carefully examined, and the following tables embody my results, the curves being those of changes in pulse-rate.

Experiment I. Temperature of the air 51·5° F. Nude at 11·57 P.M. Lay down on floor, carpeted, on right side, at 11·58 P.M., with head on footstool. Did not feel cold. Got up and

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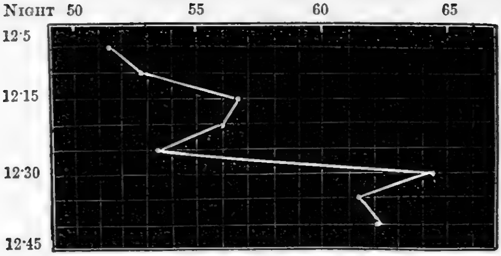
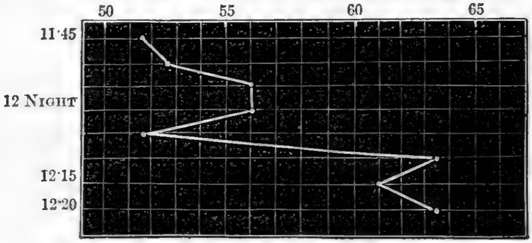
[1] *Proceedings of the Royal Society*, 1869, p. 419.



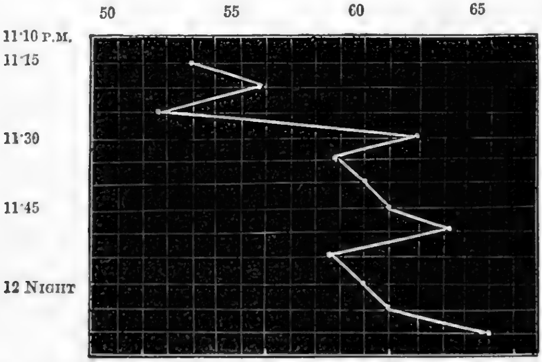
put on night-shirt and jumped into bed at 12·29; a skin glow came on at 12·29. Same position maintained in bed as when on carpet.

Experiment II. Temperature of air 50° F. Nude at 11·40 P.M. and lay down on right side. Experiment conducted exactly



as the last. Got up at 12 night, and in bed in less than a minute. A glow came on at 12·6.

Experiment III. Temperature of air 52·5° F. To shew that the change in pulse-rate did not depend on the effort of



getting into bed. Experiment conducted exactly as the first. Nude, lying on right side, at 11·7 P.M. Got up at 11·26 P.M., put on night shirt, took it off again and lay down again on floor. Got up again at 11·45′5″ and went into bed, in night-shirt. A glow came on at 11·54′5″ P.M.

From these observations it is apparent that the effect of simply altering the condition of the cutaneous vessels, by varying their relations to external agencies, varies the pulse-rate in a definite manner; and thermometric results shew that on warming the skin, as by covering it with bad conductors, the vessels are increased in calibre and the arterial resistance reduced. These experiments therefore shew that reducing the resistance quickens the pulse.

Marey's own observations, specially as they are recorded mostly by the graphic method, are of themselves sufficiently convincing on this point. He compressed the abdominal aorta of a horse, per rectum, and found the pulse thereby rendered much slower. The same result followed compression of the human femoral arteries.

The quickened pulse produced by the Turkish bath (in one case reaching the extreme rapidity of 172 in a minute on myself) is well known; as is the slow one following a cold bath, as shewn by Drs Bence Jones and Dickinson.

From these many facts, all tending in one direction only, it may be stated that the rapidity of the pulse varies inversely as the resistance to the flow of blood from the arteries.

2nd. *The relation of the pulse-rate to the amount of blood in circulation, or to the blood pressure in the arteries.*

The following experiments were made—

Experiment IV. An old donkey which had been standing for more than half an hour in the room in which the experiment was conducted, had at 7·30 A.M. a pulse of 34 a minute. At 7·40 half an ounce of chloral hydrate was given it in 2oz. of water.

At	Pulse a minute.	
7·50′	46	standing unsteadily as if intoxicated.
7·52′		it fell down asleep.
7·55′	43	
7·59′	40	
8·8′	48	a tap having been put in the jugular vein but no bleeding having occurred.

At	Pulse a minute.	
8·12′	52	Bleeding slowly from jugular.
8·15′	67	minute after minute, the animal having lost altogether about one pint or a little more of blood.
,,	64	
,,	62	
,,	60	
8·19′	59	Bleeding freely.
8·20′	52	Bleeding ceased
8·21′	49	,, ,,
8·22′	48	,, ,,
8·22′ 30″		Bleeding resumed
8·23′ 30″	49	Bleeding. Resp. 11·5.
8·24′ 15″		Bleeding ceased after loss of another pint and half.
8·24′ 30″	43	Bleeding ceased.
8·25′ 15″	42	No bleeding. Resp. 11·5
8·26′	42	,,
8·28′ 15″	42	Bleeding freely.
8·30′ 30″	42	,, ,, Resp. 13·
8·34′ 30″	37	,, ,,
8·36′	38	,, ,,
8·40′	37	,, ,,
8·42′	35	,, ,, Resp. 14·
8·45′	36	,, ,, Resp. 16·

and from this time until 9·10′, by which time more than half a pailful of blood had been lost and the carotid pulsations were very feeble, the pulse remained at 35·5 to 35 in a minute, with the respirations varying from 12 to 13 in the same time, and the loss of blood being continuous throughout.

The animal did not move once through the whole experiment.

Experiment V. A terrier dog had 30 grains of chloral given it in two doses, 15 grains first and another 15 grains about an hour afterwards. This did not render it quite comatose, so it sniffed chloroform until insensible, when a hæmadynamometer was connected with one of its carotids, and a pressure of 6·6 inches was immediately registered, which was steadily maintained, undulating with the respiration.

	Resp. in a minute.	Pulse in a minute.	Pressure.
	40	186·5	6·45 inches
In 3 minutes	42	192	6·3 „
2	40	188	6·4 „
2	...	184	6·4 „
2	49	182	6·6 „
1	52	164	6·85 „
1	...	159	7· „
1	...	150	7· „
1·5	70	138	6·9 „
4	...	142	6·7 „
5	...	149	6·8 „
6	...	156	5·8 „
7	...	168	6·4 „
6	...	102	1·7 „
10	...	129	2·1 „
5	...	138	1·9 „
2	...	141	2·1 „
3	64	142	2·1 „
5	...	138	1·9 „

In this experiment the bleeding occurred from the carotid, and took place between the pulse-countings, which were traced on a revolving drum. The great fall in pressure indicates the excessive bleeding in one case. In others a much less quantity of blood was lost on each occasion.

There was no bleeding after the fall in pressure to 1·7 inches and from that time the pressure and pulse became less and less till the animal died.

Experiment VI. A rabbit was made comatose by 15 grains of chloral, and was bled to death, the whole operation taking half an hour. An hæmadynamometer was connected with the carotid, and the blood was lost from the jugular of the same side, in drops continuously. The pressure at first, at about 6 inches, fell at the end of the experiment to less than one inch, when death occurred. The following are the pulse-rates taken at equal intervals during the half hour.

	In 10 seconds.	In 10 seconds.
	42·5	42·75
	41·9	43·
	44·	42·
	43·	42·
	42·75	42·5
	41·	41·5
	43·	42·
Bleeding began	46·	42·4
	44·5	41·
	45·5	41·75
	44·75	42·
	43·25	42·
	44·	41·
	45·	41·
	43·5	42·
	43·9	40·6
	43·	42·
	42·	42·
	43·	39·

Experiment VII. A rabbit under the influence of 15 grains of chloral—

When	pressure	4·8	inches.	Pulse	136	in a minute.
„	„	4.3	„	„	133	„
„	„	2·8	„	„	127	„
„	„	1·7	„	„	132	„
„	„	2·8	„	„	133	„
„	„	2·4	„	„	158	„
„	„	1·9	„	„	144	„
„	„	1·1	„	„	133	„
„	„	·75	„	„	136	„
„	„	·9	„	„	127	„

Death from loss of blood.

From these experiments it is evident that the pulse does not increase in frequency with loss of blood, as it did not do so in any one of them.

In Experiment IV. the pulse-rate rose on making the incision in the skin necessary to expose the jugular vein, and continued to do so shortly after bleeding commenced, but soon diminished, and after reaching 36 a minute remained perfectly constant, notwithstanding a continuous and considerable loss of blood from the vein until the animal was almost exsanguinated.

With the rabbits the difficulty in keeping them completely under the influence of the hypnotic, with the tendency to struggle, makes the results less uniform, but in all the cases there was a fall in pulse-rate, not a rise, accompanying the reduction in blood-pressure. This fall, which was not very great, may result from the cooling of the surface, consequent on the lessened circulation.

From these observations it may be concluded that variations in the amount of blood in circulation do not vary the rapidity of the pulse, and consequently that the pulse-rate is not dependent on the blood-pressure, as Marey supposed.

The next question was—What law as to the frequency of the heart's beats would satisfy these two above proved facts, namely, the dependence of the pulse-length on the arterial resistance and its non-dependence on arterial pressure?

The method adopted by Mr Fleeming Jenkin for detecting the insulation of long cables at different times occurred to me as being subject to exactly similar laws, the time of fall of cable charge from tension to half tension, which he employs, varying directly as the leakage, and as that only.

Can it be that the heart always recommences to beat when the tension falls a certain invariable proportion, and then only? This theory it was my next object to analyse, and the different elements into which it resolves itself were, and will be now, considered separately.

First, as to the full meaning of the term,—a uniform circulation. A uniform circulation is one in which the quantity of fluid flowing through all cross sections of the circulating system is the same; for if the flow through one part were less than through another, there would be a tendency for the fluid to accumulate in front of the obstruction, which is incompatible with the premises.

As a consequence of this, the heart must always recommence to beat directly as much blood has left the capillaries as was sent out from it in the previous pulsation, and therefore the length of the pause or diastole must depend on the relative capacities of the heart and of the arterial system, and on the rapidity of the flow of blood through the capillaries.

At this point the work of Poiseuille respecting the flow of fluids through capillary tubes is invaluable. He found[1] that, other things being the same, the flow of fluids through capillary tubes varies directly as the pressure. These results were verified by a Committee of the Academy of Sciences; and, by an entirely different method, I have been enabled to do the same on the vessels of the animal system.

My method was the following in a particular case.—The kidneys of a deer, with the aorta and renal vessels intact, were removed from its body and placed for some time in water at 100 F.; the aorta was ligatured just below the origin of the renal arteries, and a uniform glass-tube was tied into it just above them. Water at 100 F. was poured into the tube and it distended the organs; the tube was maintained full by a continuous supply which was suddenly stopped, and the time of fall of the column from tension to half tension at different initial pressures observed, and it was always found that it took exactly the same time to fall from 40 inches to 20 inches as from 20 inches to 10 inches, thus verifying the law.

This law being thus true, it is evident that if the capacity of the arterial system, including the left ventricle, varies directly as the pressure, then the heart must always recommence to beat when the arterial tension has fallen a certain proportion; for with double pressure, and consequently double amount of blood, the time of flow through the capillaries is constant, as the flow varies directly as the pressure; and with double resistance and unvaried pressure the time of flow is double also, for the heart pumps again when as much has gone from the capillaries as it has sent into the arteries, and the relative capacities of the heart and arteries do not vary according to the assumption.

But does the capacity of the arterial system vary as the pressure?

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[1] *Recherches expérimentales sur le mouvement des liquides dans les tubes de très-petits diamètres. Rapport de l'Académie des Sciences. Comptes Rendus.* Tome IV. 1842.

This is a point which it is very difficult to prove. With regard to the heart the following facts bear on it. By connecting a syringe with the coronary arteries, or by tying it into the aorta and pumping backwards, it can be shewn that increasing the pressure in the coronary arteries increases the capacity of the ventricles. Also in many post-mortem examinations the heart is found with the ventricular cavities fully obliterated, and as they are not then in action, the capacity of the heart and the pressure in it are at a minimum together. This is all the direct evidence that it is in my power to bring on this point.

With regard to the arterial system and its capacity, the absence of blood in the arteries after death has been known from time immemorial, and if their capacity varied directly with the pressure, it is evident that that must be the case, both capacity and pressure being at a minimum.

A direct method of determining this point having occurred to me, the following description will illustrate it. In a rabbit one of the carotids was put in communication with a kymographion; and during the time the recording drum was revolving, the chest was suddenly opened and the ventricles cut across transversely. The pressure fell rapidly to zero, and it is clear that the fall must have arisen from the escape of the blood through the peripheral vessels, as the aortic valves would close immediately. The curve of descent would take a definite form, which is easily expressed in mathematical language, if the capacity diminished as the pressure. Unfortunately the time required to open the chest, and other difficulties connected with the operation, prevented my results from being of much value; and Dr Michael Foster suggested to me that the same object would be attained if the heart were made to stop by the action of the interrupted current on the pneumogastric nerve. Mr Martin, of Christ's College, Cambridge, kindly sent me some traces thus taken, and one of the two which are suitable for measurement entirely conforms with the law, that the capacity of the vessels varies directly as the blood-pressure, assuming Poiseuille's law to be correct. The other curve does not exactly fulfil the requirements, but varies very little from them. When further opportunity occurs, I hope to repeat these experiments on a larger scale.

It can also be shewn in other ways that the arteries do not obey the laws of ordinary elastic tubes. They are covered by a dense, scarcely elastic, fibrous coat which limits their distension, and they are surrounded by organs and muscles which are pressing on them in all directions. So it may be said at least that they do not vary in capacity as simple elastic tubes, and that the difference is towards their varying directly as the pressure.

However, the indirect evidence proves that the capacity of the arterial system, the ventricle included, varies directly as the pressure: for the facts above considered as to the frequency of the pulse depending on the resistance, and *not at all* on the pressure, can only be explained on this assumption.

If the direct evidence as to the capacity of the vessels had been contradictory, it is true that it would have been necessary to assume some error in the method of conducting the pulse experiments; but, as above shewn, it is quite in the right direction, and only lacks partial direct verification.

So much in the verification of theories connected with Physiology must depend on the way in which collateral facts are explained by them, that it will be advisable now to consider some of them; and these considerations will be divided into two sections,—1st, The explanation of the known variations in pulse-rate in health, and 2ndly, The explanation of the cardiograph laws.

1st. *Variations in Pulse-rate in Health.* With regard to these points, as on this theory change in pulse-rate can only depend on change in arterial resistance, it is evident that Marey's law will, upon his supposition as to the relation between blood-pressure and arterial resistance, explain the phenomena equally well.

The following are some of the best known:—

The effects of Respiration on the Pulse-rate.

Physiologists, though not completely agreed as to the effects of respiration on the pressure of the blood in the arteries, all acknowledge that during inspiration the pulse quickens, and during expiration it gets slower, whether the pressure rises or falls. The theory under consideration clearly shews that this must be so, for during inspiration the expansion of the chest must reduce the pressure in the intra-thoracic aorta, and consequently its contained blood must fall in tension more rapidly than if the chest were motionless, and the more rapid tension fall causes increase in pulse-rate. In expiration the opposite occurs, diminution in chest capacity reduces the size of the aorta, and consequently delays the time of fall of tension, and therefore slows the pulse.

If other remote effects of respiration tend to modify the pressure in the vessels, it is evident that they would co-exist with the above and influence it but slightly, explaining the existence of the experimental discrepancies.

The effect of position of the body on the Pulse-rate.

The experiments of Dr Guy led him to explain the differences in pulse-rate following change of position as depending on the amount of muscular effort necessary to maintain the positions assumed, and his explanation, assuming that muscular effort of itself can change pulse-rate, is very complete. It is curious that the theory under consideration gives an interpretation of the same facts, though very different from that of Dr Guy.

The following are the most essential facts. The pulse is quickest while standing erect, slowest while lying, intermediate while sitting, slow while standing leaning and while supported entirely, as by being bound to a wheel in any position.

The following is the explanation. While standing, the only soft parts of the body which support the weight of the body are the soles of the feet, and the weight is transmitted to them through non-vascular and rigid tissues, cartilage and bone. Consequently the blood flows freely through almost all the vascular system unobstructed. But while lying, most of the weight is supported by highly vascular tissues, as the shoulders, arms, thighs and legs, and consequently much of the circulatory system is greatly reduced in capacity from the compression it experiences, and considerable resistance to the flow of blood is introduced into the system, the fall of tension is retarded, and the pulse therefore rendered slower.

In sitting, an intermediate condition is the result, and an intermediate rate of pulse is produced.

Leaning while standing, and entire support on a wheel, both by introducing resistance from compression of soft parts, tend to make the pulse slow.

Thus, according to Dr Guy's assumption, the slow is the normal pulse, and the quick the induced; upon the fall of tension theory the reverse is the case. The occurrence of bed-sores and the paleness of a compressed part prove that pressure disturbs the uniformity of the circulation.

The rapid pulse after a meal, during digestion, depends on the relaxation of the vessels of the alimentary canal while its functions are being performed.

(To be continued.)

A CONTRIBUTION TO THE VISCERAL ANATOMY OF THE GREENLAND SHARK (*Læmargus borealis*).

By Professor Turner

Read before the Royal Society of Edinburgh, March 17, 1873.

Naturalists have recorded a few instances of the capture of the Greenland Shark in the British seas. Dr Fleming states[1] that one was caught in 1803 in the Pentland Firth, and that one was found dead at Burra Firth, Uist, in 1824. Mr Yarrell[2] refers to a specimen caught on the coast of Durham in 1840, which has been preserved in the Durham University Museum. In May 1859 a specimen, about ten feet long, was caught in the Firth of Forth near Inchkeith, the stuffed skin of which is preserved in the Edinburgh Museum of Science and Art. In April 1862, a specimen was caught on the Dogger Bank and brought into Leith. A brief description of its external characters was read by Mr W. S. Young to the Royal Physical Society of Edinburgh[3]. On April 27, 1870, Dr John Alexander Smith read before the same Society a notice of a female specimen caught about 30 miles east of the Bell Rock. It had become entangled in one of the deep sea fishing lines, many of the hooks attached to which had stuck into its body. It measured about 15 feet in length and 3 ft. 1 in. between the tips of the tail lobes. The stuffed skin of this fish is also preserved in the Edinburgh Museum of Science and Art.

In the month of February of the present year three specimens were caught by fishermen at sea some miles east of the Bell Rock and brought into Broughty Ferry. One was taken to Dundee for exhibition, the others were brought to Edinburgh for the same purpose. By permission of the proprietors I was enabled to examine the latter specimens, and to acquire for the Anatomical Museum the viscera and other parts. One was a large female 11 ft. 8 in. in length, the other a smaller female 8½ feet long.

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[1] *History of British Animals*, 1828.

[2] *British Fishes*, 1841, p. 528.

[3] *Proceedings*, May 7th, 1862.

The skin possessed the characteristic shagreen structure, and in colour was bluish-gray. The sides of the body were barred with faintly marked narrow stripes, about 1 inch asunder, which extended transversely from the dorsal mesial line towards the ventral surface. These stripes were due to a somewhat darker colouration of the integument along the bars than in the intervals between them. The lateral line was distinctly seen on the side of the body, and the mucous canal corresponding to it ramified anteriorly both on the upper and under surfaces of the head. Thick mucus oozed through the pores of the canal on to the surface of the skin[1]. The following measurements of the larger specimen were taken[2].

	ft.	in.
From tip of snout to end of tail	11	8
... ... to back of 1st dorsal fin	6	0
... ... to back of 2nd dorsal fin	9	0
... ... to anterior edge of ventral fin	7	9
... ... to anterior edge of pectoral fin	3	5
... ... to nostril	0	5
... ... to spiracle	1	6
... ... to eye	1	0
... ... to mouth	1	2
Height of 1st dorsal fin	0	7
... 2nd ...	0	5¼
Length of pectoral fin	1	8
Breadth of „	1	1
Length of ventral fin	1	3
Breadth of ventral fin from cloacal aperture	0	11
Between tips of tail-lobes	2	9

Snout short and bluntly rounded. Nostrils situated on under surface of snout and near its outer edge. Spiracles on

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[1] The figure of this Shark given by Scoresby (*Arctic Regions*) errs in making the snout too pointed, and in placing the gill apertures too far in front of the pectoral fin. Couch (*British Fishes*) errs in the same particulars, and moreover makes the colour ash-grey, instead of bluish-grey. He represents, however, the barred appearance of the side of the body, though he does not make the stripes sufficiently numerous. Yarrell's figure gives a much better representation of the fish, and is correct in the position of the gill-openings.

[2] All the dimensions given in this paper, except when otherwise stated, are from the larger of the two sharks.

a line with outer edge of snout, 4½ inches above and behind the eyes, also behind a line drawn vertically from the angle of the mouth. 5 gill-apertures on each side lying in an oblique line in front of the pectoral fin, the posterior opening being so close to the root of this fin, that the membranous lining of the aperture was in contact with the surface of the scapular arch. Each opening was 5 inches in vertical diameter, and the distance between the anterior and posterior aperture was 9½ inches. The greatest depth of the body of the fish, immediately in front of the 1st dorsal fin, was 3 ft. 9in., the girth at the root of the tail was 1 ft. 4 in.

Attached to the cornea of one of the eyes of the smaller fish was a specimen of the parasitic crustacean named *Lerneopoda elongata.* This remarkable parasite was first observed on the eye of the Greenland Shark by Dr Scoresby, but its true character was not understood until Professor Grant published a description of it[1]. Some additional particulars of its mode of attachment to the eye were given some years ago by Dr H. S. Wilson and myself, in an appendix to a memoir on *Lerneopoda Dalmanni*[2].

The transverse diameter of the mouth was 15 inches. Eight rows of teeth with truncated cutting edges were arranged transversely on the lower jaw. One row was placed on the free margin of the jaw, and formed the line of the cutting edge; one row was situated on the outer surface below this line, and six rows lay in successive tiers on the inner surface which had not yet reached the cutting line. The two deepest of the inner series were rudimentary both in shape and size, and seemed to be invested by the mucous membrane. Seven transverse rows of sharply pointed teeth projected from the free surface of the upper jaw. The mouth was lined by a smooth mucous membrane stained with grey pigment, which was prolonged into the canal of the spiracle which opened between the cartilage of the upper jaw and the great cartilage of the skull. The mouth opened directly into an œsophagus, equal in calibre almost to the mouth itself.

When the abdominal cavity was opened an enormous

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[1] Brewster's *Edinburgh Journal of Science*, 1827, p. 150.

[2] *Trans. Royal Society, Edinburgh*, 1862, p. 85.

2-lobed, pale-yellow, oil-containing liver was exposed, which broke away by its own weight, when it lost the support of the abdominal walls.

The stomach was a capacious sac, and empty, some viscid yellow mucus coating its inner surface. Anteriorly it opened into the wide and short œsophagus. A few inches in front of its posterior end it had a transverse diameter of 14 inches. It then abruptly diminished to a breadth of only 5½ inches and formed a short *cul-de-sac*, rounded posteriorly, which I shall name the pyloric compartment, and from which the pyloric tube arose 2 inches in front of its rounded end. A slight constriction externally marked the separation of the pyloric compartment from the general sac of the stomach, whilst internally they communicated by an orifice, large enough to admit the fist, bounded by a fold of the mucous membrane. The mucous membrane of the pyloric compartment, like that of the stomach generally, was elevated into small and very tortuous closely arranged folds, which resembled on a small scale the convolutions of the cerebrum. This arrangement differed from that usually found in sharks, but was apparently not unlike what Duvernoy has described in *Galeus thalassinus*[1], though in the latter the convolutions were probably of larger size. The pyloric tube communicated with its compartment by an orifice which barely admitted the little finger, and after curving forwards for 6 inches it opened into the duodenum by an orifice so small that the tip of the little finger only could be passed into it. The internal diameter of the pyloric tube was 1 inch at its commencement, but it tapered so as to be not more than half an inch at its duodenal end. Its mucous lining was quite smooth, and contrasted in a marked manner with the corresponding membrane both in the stomach and duodenum.

The duodenum was a cylindrical tube 3 ft. 2 in. in length, which at first ran forward for 14 inches, then, bending at an acute angle, passed straight backwards for 24 inches, where it was constricted, partially surrounded by a collar-like fold of mesentery, and became continuous with the part of the in-

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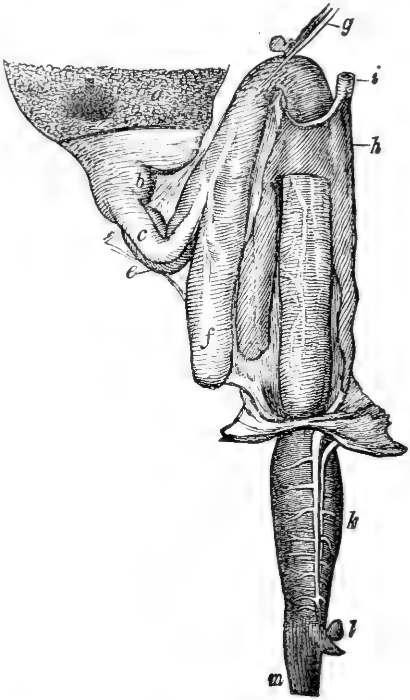
[1] Cuvier, *Leçons*, IV. 2nd Part, p. 166. This shark is the *Thalassorhinus vulpecula* of Valenciennes, Müller and Henle.

testine also straight in its direction, which contained the spiral valve. The spiral valvular part of the intestine was 13 inches



DESCRIPTION OF FIGURE 1.

a. hinder part of great sac of stomach. *b.* pyloric compartment. *c.* pyloric tube. *d.* duodenum. *e.* shorter and *f.* longer duodenal cœca. *g.* bile-duct. *h.* pancreas. *i.* great pancreatico-intestinal vein. *k.* spiral valvular intestine. *l.* glandular body. *m.* rectum. The arrow is placed in the aperture of communication between the great sac of the stomach and the pyloric compartment.

long, and terminated behind in the rectum, which extended for 7 inches backwards to the anal orifice. The total length of the intestine was 4 ft. 10 in. The external circumference of the duodenum was 5½ inches. Its mucous lining was flocculent and villous.

Continuous with the duodenum, immediately opposite its pyloric orifice, was a cœcum (*e*), 6 inches in length, which possessed almost the same internal diameter as the duodenum itself. The cœcum was not free, but lay parallel to, and so intimately blended with one side of the wall of the pyloric tube, that it required a careful examination to recognise that two distinct tubes were enclosed within a common peritoneal investment. Its cœcal end was in contact with the wall of the pyloric compartment of the stomach. Its canal was in line with the duodenum and had a similar villous mucous membrane, so that the duodenum seemed rather to be a continuation of the cœcum than of the pyloric tube. Seven inches beyond the mouth of the pyloric tube a second cœcum (*f*) 18½ inches long opened into the duodenum by a wide orifice 1¼ inch in diameter. It extended backwards, enclosed in a fold of peritoneum, parallel but distinct from the straight part of the duodenum, to terminate in a free rounded end. This cœcum was 4½ inches in circumference, and lined internally by a flocculent, villous, mucous membrane. The pancreatic duct entered the wall of the duodenum in the retreating angle of its bend, and the hepatic duct pierced it in nearly the same locality.

The valvular part of the intestine was dilated so as to have, when distended, an external circumference in its widest part of 12 inches. The coats of the gut, at the constriction which separated the duodenum from the valvular part, were very thick, and the lumen of the tube barely admitted the tip of the index finger. The valve formed a broad thin membranous band, which made 23 turns, each of which lay almost transversely and extended so far into the lumen that but a narrow central passage was left. The mucous covering of the valve was smooth on the surface. The transverse arrangement of the folds of the valve was indicated by the circular course of the branches of the intestinal artery and vein, the outline of which could be seen on the surface beneath the serous membrane.

The terminal part of the gut, or rectum, not so dilated as the valvular part, was distinguished by longitudinal markings on the outer surface owing to the fasciculated arrangement of the muscular fibres. The anus opened into the cloaca immediately in front of the two ureters. Four inches in front of the anus an ovoid body two inches in length was attached to the wall of the rectum. It was invested by peritoneum continuous with that surrounding the gut, and a prolongation of the same membrane passed from it to an adjacent part of the wall of the abdomen. A duct opening into the rectum passed along the centre of this body nearly to its free end. The inner coat of this body was formed of a softish material continuous with the smooth mucous coat of the rectum. It had the appearance of a gland, and without doubt discharged a secretion into the canal of the duct. A similar body probably exists in the Sharks and Rays generally, and to it Duméril, who recognises its glandular nature, applies the name of *appendice digitiforme*[1].

The pancreas was in close relation to the posterior straight part of the duodenum. Its body, flattened and quadrate in form, was 6 inches in breadth and lay across the intestine. From the posterior angles two elongated processes passed backwards, one for 18 inches, the other for 21 inches, and the latter was much more attenuated, especially at its free posterior end. These processes lay parallel and connected to the straight part of the duodenum by a fold of peritoneum, and the shorter one occupied the interval between that part of the intestine and the larger of the two duodenal cœca. The surface of the gland was quite smooth, invested by peritoneum, and showed no appearance of a lobular subdivision. The duct was concealed in the compact substance of the gland and sent a branch along the centre of each of the elongated processes. The duct emerged from the body of the pancreas at one of the anterolateral angles, and after a course of 4 inches in a peritoneal fold, it pierced the wall of the duodenum, through which it ran obliquely, and twisted upon itself before it opened into the canal of the gut at the summit of a small papilla.

The hepatic duct, 14 inches in length, also enclosed in a fold of peritoneum, pierced the wall of the duodenum 1½ inch from the place of entrance of the pancreatic duct, and after an oblique and twisted course opened at the summit of a papilla situated on the opposite wall of the duodenum to the orifice of the pancreatic duct.

Enclosed within the same fold of peritoneum as the bile-

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[1] *Hist. Nat. des Poissons*, I. 157. Monro figured it as an Appendix vermiformis in the Skate. E. Home figured it in *Spinax;* Owen refers to it, *Vertebrates*, I. p. 424, fig. 352; and Gegenbaur, *Vergleich. Anat.* fig. 267, figures it in a *Squatina*.

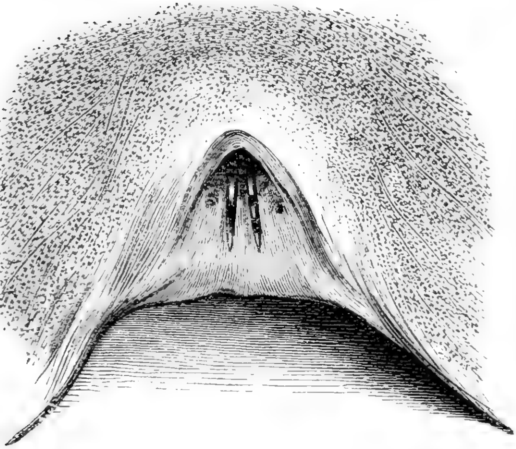
duct, at about two inches from the duodenum, was a bi-lobed body (below *g*, Fig. 1), each lobe of which was the size of a small almond. From the more anterior of these two lobes a slender cord, which seemed on external examination to be solid, passed forwards parallel to the bile-duct. On transverse section a canal, so fine as only to admit a bristle, but bounded by a thick wall, was seen in the centre of this cord. This canal passed into the lobes, where it apparently formed a convoluted tube, for on making a section through the lobes it was repeatedly cut across, sometimes transversely, at others obliquely. In the more posterior of the two lobes the calibre of the tube was less than in the anterior, or than in the cord, but whether this arose from a diminution in the size of the tube itself, or because it subdivided into smaller branches, I cannot say. A large part of the substance of each lobe was made up of a dense fibrous tissue, continuous with the thick wall of the duct, which, on microscopic examination, was found to be largely composed of pale smooth fibres, resembling involuntary muscle, mingled with which was a nucleated protoplasmic substance, in which an arrangement into not very well defined caudate corpuscles could occasionally be seen. Sections through the tubes showed an appearance which indicated the presence of an internal epithelium, but from the length of the interval between the death of the animal and the time when the microscopic examination was made, neither the form of the cells, nor their method of arrangement, could be satisfactorily determined. It is not very easy to pronounce an opinion on the function of this small organ. It resembled in many points a convoluted or compound tubular gland, the secretion of which could be expelled by the muscular wall of the duct. But this secretion was not poured into the intestine, for the duct passed away from it towards the liver. Whether it reached that organ, or had some other mode of termination, I am unable to say, as the duct had been cut short in eviscerating the animal, and before indeed it had been observed. It is possible that it may have communicated with the bile-duct, for, as is well known, the bile-duct has, in many animals, gland structures not unfrequently opening into it.

A large mesenteric vein passed forward from the spiral part of the intestine, and reached the hinder end of the more attenuated limb of the pancreas. It ran forwards in close contact with this part of the gland, receiving in its course veins from the pancreas and duodenum, and at the anterior border of the gland it was joined by a large vein coming from the opposite limb, into which a number of small duodenal veins had opened. The great pancreatico-intestinal vein was almost equal in size to the human inferior vena cava.

The spleen was attached by a gastro-splenic fold of peritoneum to the stomach. It was 17 inches long and 6 inches wide anteriorly, but was much more attenuated in its middle and posterior two-thirds. Its surface was marked by many deep fissures, which mostly ran longitudinally and gave to its surface a corrugated appearance.

The kidneys lay one on each side of the spine and extended backwards almost to the cloaca. At the hinder end of each gland the ureter became free, and the two ducts opened close together in a shallow fossa at the back of the cloaca.

The ovaries, two in number, were situated in the anterior part of the abdominal cavity, and connected to its dorsal wall by a fold of peritoneum. Each ovary in the larger shark was 23 inches long, and consisted of numerous parallel folds or laminæ which lay obliquely. The folds were attenuated along their line of attachment to the mes-oarium, but were club-shaped and succulent at their free ends. Multitudes of ova were seen in the fibro-vascular stroma, the smallest of which were mere specks, others again corresponded to shot of different sizes, and a few were as big as small bullets. Extending along the mes-oarium close to the attenuated ends of the folds was a thin-walled blood-vessel, into which an injecting pipe was introduced, and a carmine and gelatine injection gently passed into it. The vessel and its branches at once became distended, and the injection at the same time passed into a system of freely anastomosing spaces both in the mes-oarium and in the ovarian substance. These spaces swelled up so rapidly and continuously as to give one the impression, not of an extravasation, but of the existence of a cavernous vascular arrangement into which the injection freely passed. When examined microscopically the injection was seen to be contained in a net-work of dilated vessels, which often presented



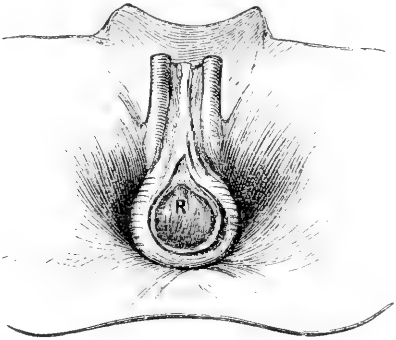
DESCRIPTION OF FIGURE 2.

Cloacal region of Greenland Shark. The bristles were introduced into the two ureters. The rectum opened into the darkly shaded hollow in front of the bristles. The abdominal pores may be seen one on the outer side of each bristle.

bulgings or varicosities on their walls. The coats of these vessels seemed to consist merely of a nucleated membrane, so that the vessels themselves may be regarded as colossal capillaries: though as regards size it should be stated that they were by no means uniform; for whilst some were but little larger than ordinary capillaries, the greater number exceeded these in diameter five or six times.

Distinct puckerings, radiating from a central depression, were observed in the ovarian stroma, immediately superficial to that aspect of both the larger and smaller ova which lay next the surface, and it is probable marked the spots where the ovary ruptured at the period of discharge of the ova. In the injected part of the ovary these puckerings preserved their white appearance, and contrasted with the red injected stroma. No oviduct was seen in the abdominal cavity, and there were no oviducal openings in the region of the cloaca.

Immediately posterior to the mouth of the cloaca, where the skin was soft, smooth and pinkish, two rounded openings protected by fimbriated processes of the soft integument were seen. These openings were the abdominal pores and through



DESCRIPTION OF FIGURE 3.

View of the posterior end of the peritoneal cavity. R. the rectum transversely divided. The two ureters lie immediately behind it. On each side the funnel-shaped prolongation of the cavity leading back to the abdominal pore is represented in shadow.

them large bristles could be passed into the peritoneal cavity, which communicated with them by means of a funnel-shaped and somewhat twisted prolongation, one on each side of the terminal part of the rectum. In the smaller shark each ovary was only 14 inches long, and the ova were so small in size as to be scarcely visible.

The heart was contained in a well-defined pericardium. It had the general form and subdivisions into auricle, ventricle and bulbus (conus arteriosus) of the heart of the cartilaginous fish. The great venous sinus opening into the auricle was situated within the pericardium, and its orifice was guarded by a bi-segmented semilunar valve. The valve at the auriculo-ventricular orifice was bicuspidate, and was attached by chordæ tendineæ to the surface of the wall of the ventricle and not to projecting musculi papillares. It lay to one side of the opening into the bulbus (conus), and a pouch-like prolongation of the ventricle passed forwards in front of it. The bulbus (conus) was three inches long. Four transverse tiers of valves projected from its inner wall within $1\frac{3}{4}$ inches from its ventricular origin. The first tier situated around the bulbo-ventricular orifice consisted of six cuspidate segments, three larger and three smaller. The apices of the cusps were directed forward away from the ventricle. The surface of each cusp lying next the lumen of the bulbus was smooth, whilst the opposite surface and the free edges were connected to slender chordæ tendineæ arising either from the valves in the tier immediately above or from the wall of the bulbus itself. The second and third tiers each consisted of five segments, three larger and two smaller. The fourth tier consisted of only three small segments. The segments in the three upper tiers were not so distinctly cuspidate as in the lowest, and attached to both their surfaces as well as to their free edges were chordæ tendineæ. The attachment of the chordæ tendineæ to the surface next the lumen gave it a corrugated appearance not seen in the cusps of the tier next the ventricle. Between the most anterior tier and the end of the bulbus, where the great artery arose from it, was an interval of 1¼ inches, and around the orifice of this artery was situated a valve composed of three semilunar segments, which in form, size and arrangement closely resembled the valve at the mouth of the human aorta. The muscular wall of the bulbus though not so thick, yet had the same colour as the wall of the ventricle, and consisted of transversely striped fibres, so that it formed, like the ventricle proper, a chamber with a pulsatile wall. The aorta, on the other hand, had the usual yellow colour of a large artery. From a consideration of its anatomical characters I am disposed to agree with Gegenbaur[1] in regarding the bulbus in the *Selachia* as an elongated and to some extent independent segment of the ventricle, prolonged forward beyond it, which is homologous with the conus arteriosus in the higher vertebrates, rather than with the bulbus aortæ of the osseous fishes, and to which the name of *conus,* rather than *bulbus* arteriosus, should be applied.

So far as I can ascertain the visceral anatomy of the Greenland shark does not seem to have been previously examined by anatomists; and, as my dissections have revealed several important structural peculiarities in which this fish differs from the sharks generally, I shall now proceed to direct attention to them.

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[1] "Ueber den bulbus arteriosus der Fische." *Jenaische Zeitschrift,* p. 365, II. 1865.

The stomach possessed the "siphonal" form met with in so many fish, but the pyloric tube, instead of arising directly from the great sac of the organ, as is the case in the *Selache maxima*[1] and various other sharks, proceeded from a "pyloric compartment." Its opening into this compartment was so constricted that I at first regarded it as the proper pyloric orifice, and it was not until I had slit open both the pyloric tube and the duodenum that I recognised the former to be not the commencement of the intestine, but the tubular pyloric termination of the stomach.

The cylindrical duodenum, its very considerable length, and the absence of any dilatation, such as constitutes the *Bursa Entiana* properly so called, formed most important features of difference between this fish and the sharks generally. The cylindrical form resembled indeed the duodenum of the sturgeon, though it did not possess that double turn which Carus has figured in the intestinal tube of the latter fish[2].

The co-existence of a well-developed pancreas with two large cœca opening into the commencement of the duodenum, is an anatomical arrangement which had not previously been recognised in the Plagiostomata. If we are to regard these cœca as homologous with the pyloric cœca in the osseous fishes—and their relations to the duodenum, both as regards their situation at its pyloric end, and the continuity and structural correspondence of their coats with the serous, muscular and mucous coats of the intestine point to this homology—then a most important piece of evidence is furnished against the view so generally entertained by anatomists that the pyloric cœca are the homologues of the pancreas. Many years ago Alessandrini indeed described in the sturgeon, in addition to the pyloric coeca which are united into an irregular ovoid organ, a proper glandular pancreas opening into the intestine by a distinct duct. But his interpretation of the pancreatic nature of the gland, though accepted by Milne Edwards[3], who regards it—along with some

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[1] As figured by Home, *Phil. Trans.* xcix. Copied in Owen's *Anatomy of Vertebrates*, Vol. i. p. 416, and in other works.

[2] *Tafeln zur vergleichenden Anatomie*, Part iv. Pl. iv. Fig. xi. 1835.

[3] *Leçons sur la Physiologie et l'Anatomie comparée*, Vol. vi. p. 412, 1861. Milne Edwards also, p. 515, directs attention to the observations of Stannius on the co-existence of a pancreas with pyloric cœca in the salmon, and states

experiments by Claude Bernard, which show that the secretion of pyloric cœca differs chemically from pancreatic juice—as conclusive against the morphological identity of the two organs, has been called in question by various anatomists[1]. The great size, however, both of the cœca and of the pancreas in the Greenland shark places their co-existence in this fish beyond all question, and should Alessandrini's view of their presence in the sturgeon be substantiated, it would make another feature of resemblance between these two fish to that afforded by the cylindrical duodenum already referred to[2].

The bile-ducts did not, as Owen has described in the *Selache maxima*[3], open by separate orifices into a common pouch, which then communicated with the duodenum by a single orifice; but a long single bile-duct pierced the duodenal wall. Owing to the breaking down of the liver I was unfortunately unable to ascertain if a gall-bladder was present or absent.

In connection with the number of transverse rows of valves in the muscular bulbus of the Plagiostomata, Johannes Müller has described[4] two rows in *Carcharias, Scyllium* and *Galeus;* three in *Sphyrna, Mustelus, Acanthias, Alopias, Lamna, Rhinobatus, Torpedo;* four in *Hexanchus, Heptanchus, Centrophorus* and *Trygon;* four to five in *Raja;* five in *Scymnus, Myliobatis, Pteroplatea* and *Squatina.* As he merely enumerates the number of rows without giving any description, I am unable to say if he includes the valve at the anterior end of the bulbus, or if he restricts himself to those situated on the wall in proximity to the ventricular cavity. In either case however it is clear that there is considerable variety in the number of transverse rows in the sharks and rays. If the semilunar arterial valve be included then *Læmargus borealis* will correspond with *Scymnus, Myliobatis, Pteroplatea* and *Squatina.*

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that in the herring, perch, turbot, and one or two other osseous fishes, both organs co-exist.

[1] Cuvier, *Leçons*, IV. Part II. p. 615, Ed. 1835. Salter, *Cyclop. Anat. and Phys.*, Article "Pancreas."

[2] Since this paper was in type I have received the last published part of the *Ann. des Sciences Naturelles*, 1873, in which is an elaborate memoir by M. P. Legouis, "On the Tubes of Weber and the Pancreas of Osseous Fishes." From his researches M. Legouis concludes that all osseous fishes have a well-developed pancreas, and that the system of tubes discovered by Weber in 1827 forms the excretory duct of the gland.

[3] *Comparative Anatomy of Vertebrates*, Vol. I. p. 426.

[4] Müller's *Archiv*, 1842, p. 484.

In its genital apparatus the Greenland shark departed in a most remarkable manner from the type of structure of the Plagiostomata. It is well known that in the sharks and rays special canals or oviducts for the reception of the ova exist, and that the ova are impregnated in their passage along these ducts. In some the egg becomes invested by a case in its passage, and is then deposited to undergo development outside the body: in others the oviduct dilates into a uterus, and the development of the embryo takes place within the parent fish. But in the Greenland shark the oviducts were absent; and from the appearance of the ovary it was clear that the ova, when ripe, would be discharged into the abdominal cavity, which would serve the office of an oviduct, and pass backwards along it to be discharged by the abdominal pores. In the organisation of its genital apparatus the female Greenland shark is much less advanced than the other Plagiostomata, and exhibits, in the mode of evacuation of its ova, arrangements corresponding to those which have been described in the lamprey and other Cyclostomatous fishes. In the number of its ovaries it corresponds to the Rays and to the genera *Spinax, Scymnus, Hexanchus* and *Heptanchus*, but differs from the dog-fish, and those sharks which possess a nictitating membrane, in which, according to Johannes Müller[1], the ovary is unsymmetrical.

By Fleming, Yarrell and other zoologists, the Greenland shark has been included in the Cuvierian genus *Scymnus*, sp. *borealis*. Müller and Henle, in their revision of the generic characters of the Plagiostomata[2], limited the European species of the genus *Scymnus* to the *Liche* or *Sc. lichia,* and made for the Greenland shark the new genus *Læmargus,* and this limitation has been adopted by Duméril in his *Histoire Naturelle des Poissons,* and by Dr Günther in his Catalogue of Fishes[3]. The characters relied on for establishing this generic difference were derived from the shape of the teeth. In *Scymnus* the upper teeth are straight and narrow, the lower crooked, pyramidal, equilateral. In *Læmargus* the upper teeth are narrow, conic,

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[1] *Untersuchungen über die Eingeweide der Fische.* Berlin, 1845, p. 20.

[2] Wiegmann's *Archiv für Naturgeschichte*, 1837, p. 399, and Charlesworth's *Magazine of Natural History*, 1838, p. 89.

[3] Vol. VIII. p. 356, London, 1870.

straight or curved outwardly, whilst the lower have a transverse edge, oblique and truncate.

It may be well that we should now compare the visceral arrangements in *Læmargus* with those of *Scymnus,* so far as the latter have been recorded. Johannes Müller, in his memoir on the arrangement of the viscera in fishes, has, several times, referred to what he saw in *Scymnus lichia,* in which he found the stomach to terminate directly by its posterior end in the pyloric tube, which he says was rather short. The duodenum also formed a dome-like *Bursa Entiana,* as in the sharks generally, and differed therefore very materially from the tubular duodenum of *Læmargus.* He makes no reference to the presence of pyloric cœca in *Scymnus,* so that presumably they were absent. Further, *Scymnus* possessed a uterus, the mucous membrane of which was studded with longitudinal rows of villi, and an annular gland for the secretion of an egg-shell existed, though, he says, it is remarkable that notwithstanding the presence of the gland no egg-shell is formed.

The anatomical differences, therefore, between *Scymnus* and *Læmargus* are very much greater than those referable to the form of the teeth, on which systematic zoologists have hitherto relied in their classification. These differences indeed, more especially in the form and extent of the duodenum, in the co-existence of a pancreas with large pyloric cœca, and in the absence of oviducts, affect not only the relations of *Læmargus* to *Scymnus* but to the sharks generally, and call for a reconsideration on the part of the zoologist of the place which the Greenland shark ought to occupy amongst the Plagiostomata, and require the establishment of a separate family for the reception of the genus *Læmargus.* This family would exhibit the following characters:

LÆMARGIDÆ.

No nictitating membrane; two dorsal fins; no anal fin; duodenum cylindrical; both a pancreas and duodenal coeca; in the female no oviducts.

Læmargus. Dorsal fins short, the second not quite so high as the first; lower teeth oblique, truncate.

Whether the Mediterranean species, which has hitherto been associated with this genus as *Læmargus rostratus,* possesses the same visceral peculiarities, will now need to be enquired into by those who may be so fortunate as to obtain specimens.

ADDENDUM. April 29th.

Since this communication was in type I have found in Carus and Engelmann's *Bibliotheca Zoologica* a reference to a paper by S. Kneeland, Junr. M.D., entitled "Dissection of Scymnus Brevipinna (Lesueur)," published in the Boston *Journal of Natural History,* 1847, Vol. v. No. IV. pp. 479, 485. This paper appears to have been overlooked by subsequent writers on the Plagiostomata, doubtless because it appeared in a Journal the circulation of which is limited. The shark was a female 7 ft. 5 in. long, caught on the coast of Massachusetts. Dr Kneeland briefly describes the liver; the heart with the valvular arrangements within the bulbus; the stomach and the spleen. He states that the duodenum arises directly from the stomach, and evidently considers the pyloric tube as a part of the intestine. He gives the length from the pylorus to the anus as 5 ft. 6 in. He describes and in a rude outline wood-cut figures the cylindrical form of the duodenum and the two pyloric cœca. He also figures the spiral valve and the glandular appendage to the rectum. He states that a pancreas with two lobes existed. The arrangement, both from the description and figure, closely corresponds with what I saw in *Læmargus borealis.* Kneeland however makes no reference to the morphological importance of the arrangement, nor does he recognise in how far it differs from other Plagiostomata. He states that "the ovaries consisted of two membranous sacs, on the internal border of which was a light-coloured tubuliform glandular mass filled with innumerable granules, about half the size of a pin's head: each ovary had a duct about the size of a crow-quill, extending nearly the whole length of the spinal column." The ducts, which he describes as belonging to the ovaries, were, I believe, the two ureters, their length and position corresponding with that of the kidneys, and their size being precisely that of the ureters in the Greenland Shark. He says nothing about the cloaca and the openings into it.

The *Scymnus brevipinna* has been referred both by Duméril and Günther to the genus *Læmargus.* In the arrangement of its intestinal canal and pancreas the fish described by Kneeland undoubtedly possessed the characters, not of *Scymnus* but of *Læmargus,* so that there can be no doubt that it ought to be referred to the latter genus. Günther considers *brevipinna* to be merely a synonym for *borealis,* and refers them to the same species. Duméril, however, principally on account of a difference in the relative length of the fins to that of the body, regards *brevipinna* as a distinct species of the genus *Læmargus.* Kneeland says nothing of the external characters of his specimen, except that the upper lobe of the tail was not so much prolonged as in Sharks generally, so that we have no data before us to aid in determining whether or no his fish possessed the external configuration of the Greenland Shark, or was a distinct species of the same genus. It should be stated, however, that the figure of *Scymnus brevipinna* which Dr Storer has given in his memoir "on the History of the Fishes of Massachusetts" (*Memoirs of American Academy,* Vol. IX. pl. XXXVIII. Fig. 2 and p. 235, 1867), bears a very strong resemblance to *Læmargus borealis.*

ON THE SOURCE OF NERVE FORCE. A THEORY.

By A. H. GARROD, B.A., *Scholar of St John's College, Cambridge.*

THE universally acknowledged inefficiency of any theory at present before the scientific world, to account for the origin of the force by which, through the intervention of the nervous system, organs at a distance from one another are placed in communication, makes me feel justified in publishing a theory which has been in my mind for some time, and which during that time accumulated information has not in any way shaken.

The following is my proposition:—The species of energy which exhibits itself in the form of 'nerve force,' is electricity of thermo-electric origin, resulting from the fact that the surface of the living animal body is always colder than its interior. In other words—The available energy resulting from the interior of the living animal body being at a higher temperature than that of the surrounding medium, is expended wholly, or in great measure, in generating the force called nerve force. In the discussion of this problem, the following are the considerations on which it is based.

1. The temperature of the interior of the living body is always greater than that of its surface, because all animal life is only a form of chemical degradation, and is therefore necessarily attended with evolution of heat; which, no other force intervening, will always keep the interior of the body hotter than the medium in which it lives. When the temperature of the air in higher animals exceeds or nearly approaches that of the body, which varies but little, special arrangements (perspiratory, &c.) come into play to diminish that of the surface.

2. There is an available source of energy in the body, which has been but little considered by physiologists, depending on the temperature of the surface being lower than that of the interior. The theory propounded gives employment for this force.

3. In the struggle for life, the individuals that economise the forces at their disposal are most likely to survive; it is

therefore improbable that this not inconsiderable source of energy should have escaped employment in this struggle.

4. The actual construction of the nervous system is quite sufficient for the working of such a force as the one proposed. In addition to the already known properties of the nerves, including their good conducting power, it is only required that *a thermo-electric current be capable of being generated between soft tissues of different composition or structure,* such as the extremities of the sentient nerves and the corium in which they are embedded.

Although Magnus was not able to produce any thermo-electric current between fluid metals, his experiments are not in any way conclusive against the possible existence of such currents between different tissues; the subject is in a position for actual demonstration, no doubt, and I much regret that as yet I have not had opportunities of attempting to prove or disprove it. Notwithstanding this, some of the circumstantial or collateral evidence is so strong, that, without any direct proofs, I feel justified in assuming its correctness. The following points strongly favour my theory.

1. Within certain limits, which are those to which the body is most generally exposed, the energy of the individual (which must be closely related to the supply of nerve force) is greater as the temperature of the air is less. On a cold day, in a cold air, there is more will and power to work physically than in hot weather, in a hot air, during which languor is a prominent feature. In a paper published in this *Journal* I have proved that the circulation through the skin in man varies according to the temperature of the atmosphere, and that when 70° F. of the air is reached, perspiration commences. Consequently by this means a difference of about 30° F. is always maintained in health between the surface and the interior; and exposure to the highest temperatures of the Turkish Bath, when continued for some time, does not disturb this condition. But a hot-water bath is followed by very different consequences; if the body and face be immersed in one of 100° F., and breathing be performed through a tube projecting from the mouth to the surface, as I have tried, faintness, or loss of nerve power, comes on very rapidly, and is it not because the temperature of the

surface is raised to that of the interior? At all events this explanation is as reasonable as any other. This faintness is soon recovered from on the reapplication of cold to the skin.

2. The effect of muscular exercise is to raise the temperature of the body, and so to increase the difference of temperature between it and the external air; and when great muscular exertion has to be sustained, as in rowing, most of the clothes have to be removed in order to allow of the rapid cooling of the surface, the necessity for which is keenly felt.

3. During intra-uterine life the active chemical changes going on in the body of the fœtus maintains its temperature at a slightly higher point than that of the mother; but immediately after birth the nerve force generated by the cooling of the surface brings the intercostals and other muscles into play, and the child is otherwise much more active than when *in utero*.

4. The source of the body heat being central, and the circulation of the blood tending to render that of all the parts uniform, it is evident, as a simple physical deduction, that the temperature of the portion of the body which corresponds to the heated end of the thermo-electric couple (which in the theory now under discussion can only be the brain), must be lower than that of the blood, because the heat supplied to, and developed in it (the brain), is partly employed in generating the electric current which is circulating. Dr John Davy noticed that the temperature of the brain of the rabbit was peculiarly low, considerably below that of the abdominal viscera; his results have been considered improbable by some, but have never been refuted; they are strongly in favour of my theory, which, as shewn above, explains them completely.

Upon my theory the mechanism of the nervous system may be thus summarised—

The afferent nerves are the conductors to the nerve centres of the electric current which is generated by the contact of their peripheral ends with the tissues of the cooled skin, which they supply. The brain is the largest of the centres towards which the nerve current is directed, the other ganglia forming the smaller. Through these centres the currents, as through an elaborate commutator, are split up or concentrated in a manner not understood as yet, to be directed along the efferent nerves, which are always so situated as to be beyond the reach of external cooling influences. Where an organ acts in any way automatically, it generally has centres of its own, of a size varying in degree according to its automaticity, and these minor centres are only to a certain extent subject to the influence of the brain.

As in the working of the electric telegraph, no return or second special conductor is required to carry back the current to the point from which it started; for where an efferent nerve terminates in a muscle, it loses its insulating covering, and so is put into indirect communication with the peripheral sentient nerves through the intervention of the mass of body tissue generally, which, though its resistance is much greater, offers an incomparably larger mass to be traversed by the current.

NOTE ON THE CARPUS OF THE SLOTHS. By W. H. FLOWER, F.R.S.

IT is well known that in the existing Sloths (*Bradypodidæ*), as in their gigantic extinct allies, the megatherioids, the trapezium is not present as a distinct bone in the carpus.

The absence is accounted for by Cuvier[1], Owen[2], and most other writers on comparative anatomy, by the assertion that it is united with the scaphoid. The hook-like prolongation of the latter bone towards the inner side of the carpus lends some countenance to this view, but it is nevertheless incorrect, as in reality the representative of the trapezium is to be found in what appears at first sight as an enlarged proximal end of the rudimentary first metacarpal. This may be demonstrated in the following manner.

1. The aforesaid hook-like prolongation is common to all the other Edentates, which possess the trapezium as a distinct bone, though not developed to the same degree as in the Sloths. Moreover, in the youngest Sloths which I have examined there is no sign of its being ossified from a separate centre, as would be the case if it were a coalesced trapezium.

2. The position and relations of the apparent enlarged head of the first metacarpal (especially in the two-toed Sloth or Unau) is exactly that of the trapezium of the Armadillos, Anteaters, and Pangolins, its proximal surface being rather above the level of the head of the second metacarpal, and it articulates with the last-named bone, the trapezoid and the scaphoid, whereas the head of the first metacarpal in all these animals is placed more distally than that of the second, and articulates only with the trapezium.

3. The most crucial test is afforded by development. In the skeleton of a young two-toed Sloth (*Cholopus didactylus*), No. 2387, Mus. Roy. Coll. Surgeons, the bone which has been

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[1] "Dans *l'unau*, le *scaphoïde* se soude avec l'os d'en dessous ou le *trapèze:* c'est une chose qui lui est toute particulière." "Dans *l'aï*, la soudure du *scaphoïde* au *trapèze* a toujours lieu."—*Osteologie des Paresseux.*

[2] Comp. *Anat. and Physiology of Vertebrates*, Vol. II. "Memoirs on the Mylodon, Megatherium, &c."

considered the first metacarpal in the adult consists of three distinct ossifications. *a.* a rounded nodule having the usual relations of the trapezium, and without doubt representing that bone. *b.* a smaller intermediate ossification, the epiphysis, and *c.* an elongated cylindrical bone, the shaft, of the metacarpal.

P.S. Since writing the above I observe that Professor Humphry has noted the coalescence of the trapezium with the first metacarpal in a two-toed Sloth, of which he described the muscular anatomy (*Journal of Anatomy*, Vol. IV. p. 18). The specimen is now mounted in the Anatomical Museum of the University of Cambridge; and being exactly at the best age to show the disposition of the still partially united bones most clearly, Professor Humphry has kindly allowed a drawing of them to be added in illustration of the subject (see Fig. 1).

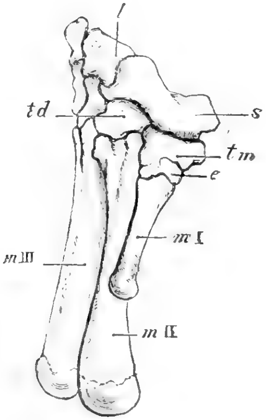

Fig. 1. Inner side of carpus and metacarpus of a Two-toed Sloth (*Cholopus didactylus*) in the Cambridge University Museum. *l.* lunar. *s.* scaphoid. *td.* trapezoid. *tm.* trapezium. *m*I. first metacarpal; *c.* its epiphysis. *m*II. second metacarpal. *m*III. third metacarpal.

ON A CASE OF HYPERTROPHY OF THE RIGHT CEREBRAL HEMISPHERE WITH COEXISTENT ATROPHY OF THE LEFT SIDE OF THE BODY

By J. Batty Tuke, M.D. (Edin.) F.R.C.P.E. *Medical Superintendent Fife and Kinross District Lunatic Asylum: visiting Physician to the Saughton Hall Institution for the Insane.*

History.—The only account his mother gives of this man, is that at birth he was not an unusually large child, nor was her confinement difficult or tedious; that when he was 10 days old a drunken man stumbled against the child's head (which side she could not remember), and that immediately afterwards epileptic convulsions set in and continued for 9 months, when they ceased. She states that the head began to grow very much after the fits commenced, and that the doctors stated to her that he had water on the brain. He never showed any evidence of intelligence as other children do, and the left side of the body was always smaller than the right.

There is no history of hereditary predisposition except that a near relative died of hydrocephalus. Her son was placed in a poorhouse when 10 years of age, when he again became subject to fits, which continued until he died.

He was clinically examined on Sept. 28th, 1871, and the following is the report.

General Appearance.—Patient is a man of average stature. The whole of the left side of the body is considerably atrophied, whereas the right appears normal. The face is drawn to the left; the left side of the face seems on a lower level than that of the right, which is fuller. The mouth is drawn to the left. The left arm is hardly half the circumference of the right. The left forearm rests at right angles to the arm, and the hand to the forearm. The whole arm is kept applied to the trunk. No anchylosis exists in either joint, passive movements can be made though there is no power of voluntary movement. The left leg is atrophied to a half, the knee is kept in an inverted position, and the foot is both slightly extended and inverted.

The knee-joint is capable of slight passive movement, but is not so as regards voluntary action. The ankle-joint is incapable of either. Progression is solely performed by the right leg, the left being lifted and carried after by the pelvic muscles.

The atrophy of the trunk is best seen in the thorax. The thorax is flat, its antero-posterior diameter being $6\frac{3}{16}$ inches; its left side is lower than the right. The circumference is $31\frac{1}{4}$ inches, the right half being $17\frac{1}{8}$ inches, the left $15\frac{1}{8}$.

The head has the following peculiarities and measurements. The forehead is low and slightly retreating. The right side is higher than the left, the vertex being formed by the right parietal bone. The occipital region is drawn towards the right shoulder. Circumference measures 22 inches, antero-posterior diameter $7\frac{7}{16}$ inches, transverse auricular diameter $6\frac{3}{16}$ inches, from ear to ear over vertex $12\frac{3}{4}$ inches, and from between supraciliary ridges to occipital protuberance $14\frac{1}{2}$ inches.

Nervous System.—The epileptic fits occur about once a week, and are of medium severity. The convulsions last about half a minute, the face being very much drawn to left shoulder. The coma is profound. The eyes do not act in a co-ordinate manner, the action of the left being impaired.

Mental Phenomena.—Expression of face imbecile; mouth always half open, saliva runs from it; smile and laugh childish. Articulation very imperfect and deficient. He can utter a few words in a childish manner. A marked feature in his case is constant singing, his great fondness for it, and the correctness of his tunes, which are limited in number. His affection is strong for his companions, but his temper is very bad and irritable. Ideation very limited, if any.

Course of Case. In May, 1872, signs of Phthisis pulmonalis were discovered. This disease made rapid progress, and he died on Oct. 2nd of the same year, at the age of 37 years.

Report of Post-Mortem Examination.

General Condition.—Body much emaciated, yet unilateral atrophy, as described in case, very marked.

Head.—Scalp thin; calvarium unequally thin, very dense, and of ivory hardness in certain places; diplöe present only on left side of frontal bone, and in one limited spot, in right. The thickness of left side of frontal bone above supra-orbital notch was $\frac{4}{16}$ of an inch, and at corresponding part of right side $\frac{2}{16}$. Other parts of the circumference were also unequal. The skull was large, the dome high, ridged at the summit, to the right of which the parietal bone was round and full, to the left it was flattened. The circumference was $21\frac{3}{16}$ in., the lateral measurement from nasal eminence to occipital protuberance on right side being $10\frac{9}{16}$ in., on left $10\frac{5}{8}$ in. The antero-posterior measurement from same points over vertex was $13\frac{5}{8}$ in., the transverse from one meatus auditorius to the other over vertex was also exactly $13\frac{5}{8}$ in., the measurement on the right side being $6\frac{6}{8}$ in., and on left $6\frac{7}{8}$ in. The depth of dome from foramen magnum was $5\frac{7}{8}$ in., the antero-posterior diameter 7 in. and the transverse $5\frac{15}{16}$ in. The capacity was $110\frac{1}{2}$ cubic inches.

The sutures were very faintly marked, ossification being very far advanced, especially in the sagittal.

The facial portion presented the following abnormalities:—the external inferior angle of the right orbit on a lower level than the left, and the right infra-orbital foramen correspondingly lower, as was also the inferior border of the right nasal aperture; in short, the right side of the face was on a lower level as a whole than the left. The molars in the right upper jaw were only two in number (wisdom tooth being undeveloped); in lower jaw the same condition existed.

External base showed a very thinned state of the bones immediately posterior to the posterior condyloid foramina; on the left side this spot was a mere shell. The left condyloid articular surface was divided into two facets. The ridges on the occipital bone were well marked.

Internal surface. The superior longitudinal sinus took a sharp turn to the left about an inch above the point of the lambdoidal suture. The sutures were indistinguishable. On the inner table of frontal bone, on either side of longitudinal sinus, were numerous small dense bony elevations to which the dura mater was adherent, especially on the right side.

The internal base presented the most marked abnormalities. Between the anterior fossæ a sharp ridge ran upwards and forwards for more than two inches, and where it ended the shallow and irregular superior longitudinal sulcus began. Both the anterior and middle fossæ were very rugose. The area of the right middle fossa was somewhat greater than that of the left. The body of the sphenoid bone was out of the mesial line to the left. The petrous portion of the left temporal bone differed in shape materially from the right; the groove of the lateral sinus of the left side had become expanded into a considerable antrum and changed the size and form of the foramen lacerum posterius. This sulcus bifurcated from the superior longitudinal markedly to the left of the mesial line, the posterior fossæ being thus rendered of different areas, the left being about half that of the right. The twist to the left of the superior longitudinal sinus caused the cerebral fossæ of the occipital bone to be unequal. The groove of the left lateral sinus was well marked. The right was very faintly indicated. A rugged exostosis $\frac{3}{8}$ths of an inch long and $\frac{1}{8}$th of an inch high grew from the upper surface of the basilar process into the cranial cavity[1].

Membranes.—At vertex, on left side, all the membranes were adherent to each other. The vessels of the pia-mater, especially the veins, were deeply injected. Lateral sinuses gorged with dark blood. A bony plate, $\frac{1}{4}$ inch by $\frac{1}{8}$ inch, was found on the first left frontal convolution about its middle, between dura mater and arachnoid, and attached to both. At the corresponding part on right side smaller particles of bone were found.

Brain—general characters.—Of large size, heavy (60 oz.), firm consistence, tough and resilient. No impression was made upon it by a column of water 5 feet in height. The left occipital lobe was perceptibly larger than the right: the relative weights of the two hemispheres were, right 30$\frac{1}{4}$, left 23$\frac{1}{2}$ oz.: the difference being 6$\frac{3}{4}$ oz. The right ascending frontal convolution was very tortuous, and the fissure of Rolando joined the great longitudinal fissure further back than usual. The fissure of Rolando on the left side did not reach the great longitudinal fissure, being bridged across at the vertex by a knuckle which

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[1] Such exostoses have been described by Virchow (*Entwickelung des Schädelgrundes*, 1857), who ascribes them to ossification of an elevation of the cartilage of the basicranial synchondrosis, and Professor Turner has noted the same condition in a scaphocephalic cranium. (Vide Paget's *Lectures on Surgical Pathology*, 3rd edition, edited by Turner, p. 531.)

joined the ascending frontal and parietal convolutions. The third left frontal convolution was much better defined than the right. On the right side, a knuckle from the second frontal interposed between the portion bordering the fissure of Sylvius and that running down to the island of Reil.

The specific gravity of the two hemispheres as proved *en masse* was exactly 1036: that of the cerebellum slightly greater. Separate portions of grey and white matter taken from various localities on both sides were tested and found to be sp. gr. 1036.

On section there was a marked difference between the grey matter of the two hemispheres as to colour and thickness. The left hemisphere had the grey matter of all its convolutions markedly darker than the opposite side; the colours were on the left dark grey, on the right light pink grey, in the outer layers; the inner ones being of a darkish brown, a white band separating them. The line of demarcation was obvious to the naked eye. The grey matter of the left side, as measured by Dr Major's tephrylometer[1], varied from $\frac{11}{100}$ of an inch in the frontal lobes to $\frac{4}{50}$ in the occipital. On the right side it was much thicker and much more even over the whole hemisphere. In the frontal and anterior convolutions of the parietal lobe the thickness was $\frac{7}{50}$ of an inch; in the posterior convolutions of the parietal (more especially the annectant convolutions) and the occipital lobe the thickness was $\frac{15}{100}$ of an inch.

On viewing the superior surface of the cerebellum, the left side was found to be one-third less in bulk than the right. The folia of the left side were narrower than those of the right. The notch or vallum was filled by an abnormal lobule, springing from the inferior surface. On inspection of inferior surface, the left hemisphere was found, although much smaller than the right, more normal in its arrangement, for its lobules were fairly defined. The vallecula was but very slightly marked. The notch was represented by a slight depression. There was no appendix vermiformis. Proceeding from above downwards on the right side, the lamellæ, immediately below the longitudinal fissure, were normal for two-thirds of their extent. The biventral lobe could be traced; also the amygdala, although its

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[1] See a description of this instrument in *West Riding Asylum Reports*, II. and this *Journal*, VII. 169.

appearance was quite abnormal, inasmuch as it was composed of several convoluted lamellæ, its shape was round, and it was unduly elevated. The slender and posterior inferior lobes were represented by a confused mass of lobules of convoluted laminæ extending right across the vallecula, and attached to the opposite side by membranes.

No difference was observed in the size of the corpora striata, optic thalami, or in any other of the organs of the cerebrum. The pons varolii was symmetrical. The medulla oblongata was markedly larger on the right side above the point of decussation. The spinal cord was symmetrical, and no difference could be observed in the size of the ganglia of the different sides. The vessels were deeply injected, and a small amount of serum was found. A marked difference existed in the calibre of the vertebral arteries, the right being about twice the size of the left.

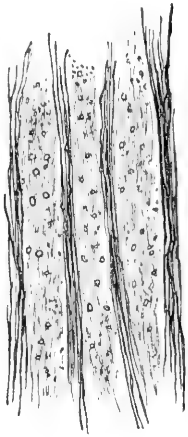
Microscopic Examination.—Cerebellum. In a specimen taken from the grey matter of the deformed portion of the right hemisphere, several well-marked cells of Purkinje were seen. Vessels normal. On the left side the nerve fibres were peculiarly distinct and large. Cells of Purkinje and molecules were seen, the former large but not very distinct. In examining a punctum vasculosum, the vessel forming it was carefully extracted, and the cellular coat was seen to be thickened, and the muscular fibres well pronounced. A considerable deposit of hæmatin was found on the outside of the vessel. In a specimen prepared in chromic acid the structures appeared nearly normal, except that the granules of the granular layer were not so closely packed as usual. In the white matter spaces of molecular matter were seen which had taken the place of fibres. This specimen was taken from the deformed left postero-inferior lobule. On the right side no abnormality was noticed.

Right Frontal Lobe.—In a recent specimen taken from the 1st frontal convolution, the nerve-cells were found in greater abundance than elsewhere. A very fine molecular deposit was observed on the vessels, and the nuclei of neuroglia and of the vessels were proliferated and enlarged. The external granular layer was productive of great numbers of irregular round bodies, of the size of a blood-corpuscle. Microscopic section of the same convolution confirmed the above. The cells of the outer layers were small, rounded, irregularly distributed, and numerous; those of the two inner layers were well-marked, normal in size and regular in arrangement, the poles long and well-defined. The fibres, although thickened, were properly distributed. In some places they were rather widely separated. The external layer was thickened.

Left Frontal Lobe.—The only difference between the 3rd frontal convolutions of either side was the definite evidence of increase of connective tissue in the right; in it 4, 5 or 6 fibres could be seen pushed together into fasciculi, between which connective tissue and nuclei of neuroglia existed in large quantities. In the white matter few fibres could be traced, although several clearing agents were employed, turpentine, glycerine, and oil of cloves. The molecular matter was increased and arranged in a fibroid manner. Taken altogether, the constituents of these lobes were more nearly approaching the normal condition than the other parts of the brain.

Right Parietal Lobe.—Various recent specimens taken from the right ascending parietal convolution, near vertex, showed the nerve-cells to be scarce and but faintly defined. A chromic-acid preparation showed the large cells of the deepest layer of grey matter well, with the poles traceable for long distances. There was a brownish molecular discoloration at their bases, but not more than is often observed in health. The smaller cells were irregular in shape and distribution and without perceptible nuclei. The increase of neuroglia was well-marked, the nuclei were much proliferated in plasm and on vessels.

Right Occipital Lobe.—In several specimens taken from this region and examined in a recent state, and by section after being steeped in chromic acid, there was seen a very evident increase of molecular matter between the nerve elements; with this were associated fine fibrillar structures. The fibres were much enlarged, and were moniliform. Both these conditions might have been to some extent due to pressure, but the experience gained from many brains, examined under exactly similar circumstances, leads to the conclusion that it was not altogether so. On the capillary vessels a small amount of very fine colourless molecular matter was sparsely scattered. The grey matter was examined in successive slices from without inwards. Very few cells were found, and these were in no way actively diseased; they were atrophied to a great extent; were small in size, irregularly shaped and ill-defined. In some chromic acid sections a fine layer of yellow molecular matter was found between the pia-mater and the brain substance, presenting the appearance of pale hæmatin. In the same sections the fibrils became fainter as they proceeded inwards; when more than half an inch from the grey matter, the fibres disappeared, and the field of the microscope was filled with fine molecular matter arranged in a fibroid manner.



Portion of white matter of right occipital lobe. The lines represent the nerve fibres. The intermediate nucleated material is the hypertrophied neuroglia.

In the Left Occipital Lobe the microscopic appearances approached more nearly to those of health. The fibres were not displaced, and there was not the same evidence of increased connective tissue. The cells were in the same atrophied condition, and did not occur in any greater number.

Remarks.—I am inclined to regard this case as one of unilateral hypertrophy of the brain, primarily due to acute hydrocephalus, and eventually resulting in atrophic hemiplegia. Although no great stress need be laid on the statement of the mother as to the causation of the hydrocephalus and the fits, the general characteristics of the calvarium indicate that the former did exist to a certain degree, and that it was due to effusion into or below the arachnoid sac. As occasionally happens the calvarium was asymmetrically dilated. The disease having been arrested after the skull had become ossified and the fluid being gradually absorbed, a compensatory substance was demanded, which was supplied by an increase of the neuroglia of the right hemisphere *pari passu* with the absorption. This sclerosis of the packing substance of the right hemisphere impairing its trophesial influence, resulted in arrestment of development of the opposite side of the body. It is a matter of everyday experience that bilateral atrophy of the body occurs in the subjects of bilateral brain disease, and that deformed and rickety dwarfs are very frequently possessed of abnormally large heads. It appears to me more than probable that in the latter class both hemispheres of the brain have undergone the hypertrophy which was demonstrated in the right hemisphere only of the case under consideration.

In Van der Kolk's[1] case of atrophy of the left hemisphere of the brain with coexistent atrophy of the right side of the body, the right hemisphere of the cerebellum, and the left side of the spinal cord were found atrophied. In the case under consideration the right hemispheres of both cerebrum and cerebellum were hypertrophied, and no difference could be detected in the size of the right and left sides of the cord, or of its ganglia; in fact, the sclerosis was symmetrical, and did not extend below the decussation in the medulla.

It may here be mentioned that this is the fourth case of disease of the cerebellum which has come under my notice. In three atrophy was the abnormal condition, and it had implicated in one case five-sixths of the organ: in the other two one hemisphere was destroyed. In none of these cases was there any psychical or physical indication during life in consonance with theories which are held by some physiologists as to the

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[1] Case of atrophy of the left hemisphere of the brain with coexistent atrophy of the right side of the body, by J. L. C. Schroeder Van der Kolk, translated by the New Sydenham Society, 1861.

functions of the cerebellum. In the three cases of atrophy there were no symptoms at all.

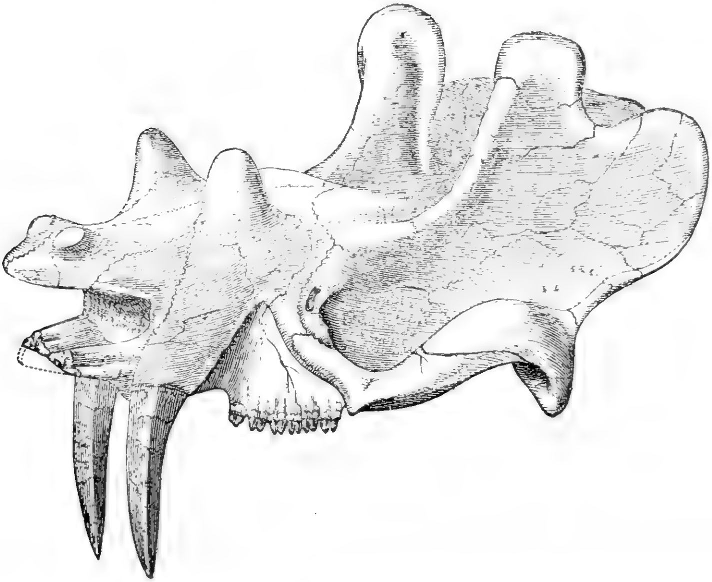
It does not appear from Van der Kolk's monograph that he determined by microscopic sections which of the brain elements were atrophied. In my case there exists no doubt that the general sclerosis produced a distinct and definite change in the continuity and arrangement of cells and fibres, and that impaired trophesis was the result. I deeply regret that the examination was not completed by accurate measurements of bones and of muscular and nerve fibres, in the same exhaustive style as characterized the researches of this eminent observer. It is more than probable that in his case the chief loss of brain substance occurred in the neuroglia; my experience at least being that it is the first of the cerebral constituents to give way. Whatever may have been the condition, it is interesting to note that both hypertrophy and atrophy produce the same results.

It is worthy of consideration to what extent the exostosis might have had influence on the epileptic convulsions and the permanent tonic spasm. I can find no definite statement as to the period of life at which ossification of the basicranial synchondrosis occurs. It is generally said to take place "at an early age," and Henle states that the suture becomes obliterated after the 20th year. The fact of the return of the epilepsy at the age of ten, is suggestive that ossification of the cartilaginous elevation may have been the cause, but nothing can be founded on the suggestion. It is more likely that the chronic tonic spasm may have depended on this constant cause of irritation: but the most probable hypothesis is that it had no effect in the production or maintenance of either epilepsy or spasm.

ON THE ORDER DINOCERATA (*Marsh*). By A. H. GARROD, B.A., *Cantab.*

IT is very seldom that specimens are now obtained, either fossil or recent, of mammalian forms that have, provisionally at least, to be placed in a new order by themselves, on account of the presence of peculiarities hitherto quite unknown and unexpected. Such, however, is the case with a large series of fossils which have been, within the last two years, obtained from the Eocene deposits of Wyoming in North America. Our chief source of information respecting these remains consists of a series of papers by Prof. D. C. Marsh of Yale College, abstracts of which have recently appeared in *The American Journal of Science*, and in *The American Naturalist*. Prof. E. D. Cope has also published several papers on the subject, and some excellent photographs of one of the most important forms, sent by him to this country, it has been my good fortune to see. Prof. Leidy has also named one of the genera. Most of my information is obtained from the papers by Prof. Marsh on the Order Dinocerata, together with the critical remarks made by him on Prof. Cope's descriptions, which I have also by me.

Dinoceras mirabilis is the name given by Marsh to a huge ungulate animal, of which there is an almost complete skeleton in the museum of Yale College. Its size must have been very nearly that of a full-grown Elephant, as the length of the skull of a closely allied genus was a little more than a yard. The skull was peculiarly long and narrow, and supported three pairs of horn cores in rows, on its superior surface. The anterior pair were situated on the anterior ends of the nasal bones, they were short, conical, and directed nearly straight upwards. The median pair were conical prolongations upwards from the maxillaries, they were longer and more cylindrical than those on the nasals, and the fangs of the huge canine teeth entered their bases. The posterior pair, the largest, were very peculiar, being extensions upwards from near the middle of large lateral longitudinal crests, which were formed by the occipital, parietals, and frontal bones. The dentition was peculiar, the upper incisors were deficient, and the premaxillæ consequently small.



Skull of *Dinoceras mirabilis*, copied from Prof. Marsh's figure, and kindly lent by the Proprietors of *Nature*.

The upper canines formed huge downwardly directed tusks, nearly straight, but directed somewhat backwards. These, after a gap equal to their breadth, were followed by six small molar teeth. Each of these was composed of two well developed nearly straight, transverse ridges, which joined at the inner border of the tooth and diverged as they ran outwards, so forming a simple >-shaped pattern, that continued well marked till the tooth was much worn. The posterior of the two ridges was quite transverse, and the anterior was slightly concave backwards, and ran obliquely forwards and outwards. These teeth diminished in size from before backwards gradually, and there were no intervals between them. All that I can find about the lower jaw is, that it was slender, and its tusks small.

The orbit was not separated from the temporal fossa, which latter was large, extending up the outer side of the lateral parieto-occipital crest. The malar completed the anterior portion of the zygomatic arch; the lachrymal was large, forming the anterior border of the orbit, a large oval foramen perforated its facial surface. The squamosal sent down a large post-glenoid process. The nasals were massive and greatly prolonged forwards, at the tip carrying the anterior horn-cores; they also sent slight processes up the inner faces of the maxillary horn-cores. The premaxillaries were peculiar in that they almost enclosed the anterior nares; they united posteriorly with the maxillaries just in front of the canines, and then divided into two branches, one of which, the lower, corresponding to the premaxillary of the Rhinoceros, ran forwards free, the other closely uniting with the adjoining nasal went upwards to strengthen the support of the horn-cores.

The extremities were tetradactylate, and in the pes the astragalus articulated with the cuboid as well as with the scaphoid bone. The humerus was short and massive, with the great tuberosity not rising above the articular head, and the condylar ridge of the distal end not continued up the shaft. The radius which was free, was not so oblique as in the Elephant. The femur had no pit on its head for the ligamentum teres, and there was not any third trochanter. The phalanges were short as in the Elephant.

The number of the vertebrae are not noted by Marsh, so that I cannot say how many there were in the dorso-lumbar region, a point of great importance. There were four in the sacrum, the last being small and supporting a slender tail. The ribs had rudimentary uncinate processes.

The name *Tinoceras* has been given by Marsh to a very closely allied species, which differs from Dinoceras in having the anterior, or nasal-horn cores compressed on the top, larger and projecting more forward; the maxillary horn-cores are also proportionately longer, more cylindrical, and directed slightly forward. The photographs of this genus above referred to shew very clearly that the palate was completed opposite the posterior molars by the palatine bones. The differences between Tinoceras and Dinoceras seem to be scarcely generic. Another closely allied genus, of which I have seen no description, is the *Uintatherium* of Leidy. The name *Eobasileus*, introduced by Prof. Cope, is a synonym of *Tinoceras*, and being of later introduction, must be sunk.

From the facts given above, Prof. Marsh is led to placing these undoubtedly peculiar animalia in an order different from any yet established, intermediate between the Proboscidia and the Perissodactylata. To me it seems much more probable that they belong to the Ungulata proper, and that no separate order is necessary for their reception. In the characters I have given, there are none which shew them to have any true Proboscidian affinities, whilst there are several which seem to indicate that they belong to a family of the Artiodactylata, and not to the Perissodactylata. Among the reasons in favour of Dinoceras and its allies being Artiodactylate are the following:

1. The astragalus has a well-developed cuboid facet.
2. The palate is complete between the posterior molars.
3. There is no third trochanter to the femur.
4. The premaxillae are edentulous.
5. The anterior premolar is not devoloped.

ON THE SO-CALLED PRICKLE OR CLAW AT THE END OF THE TAIL OF THE LION AND OTHER FELINES. BY PROFESSOR TURNER.

HOMER, in the 20th Book of the *Iliad*, when describing how the God-like son of Peleus rushed on the high-souled, warlike Æneas, compared him with a destructive lion—

> "As he lashes
> Fiercely his sinewy flanks with his tail, each side in succession
> Rousing himself for the fight."

Various authors and critics have supposed that the tip of the lion's tale is armed by a pointed sting or prickle, and that when the animal uses his tail in the manner so vividly described by the poet, he goads himself by its prickly sting prior to making a rush on his prey. Although comparative anatomists generally had taken no notice of any such structure, yet some support was given to the opinion formed of its existence by the authors referred to, by a statement made by Blumenbach in his work on Natural History, who said that he had seen something like a sting in the tail of a lion.

Some years ago this subject was investigated by Prof. Leydig, who wrote a short but interesting Essay, entitled *Ueber den Schwanz-stachel des Löwen*, in *Reichert und du Bois-Reymond's Archiv* for 1860. Leydig had examined in the previous winter the tail of a splendid lion which had died in the Zoological Garden at Stuttgart, and found, on turning on one side the hair which covered the end of the tail, a perfectly smooth and hairless papilla, *rundlich-kegelförmig* in shape, with a constricted base and an elevated apex. Leydig made a careful microscopic examination of this papilla, and came to the conclusion that it was not a special and peculiar organ, but merely a papilla of the skin endowed with vessels and nerves, so as in all probability to be an organ of sensibility like a touch organ at the point of the finger. Leydig also refers to a monograph with the title *Der Stachel des Löwen an dessen Schweifende*, published anonymously at Darmstadt in 1855, in which the author described the 'sting' or 'prickle' in the tail of a recently dead lion, and in several stuffed specimens. This author also stated that the Puma, *Felis concolor*, possessed a similar structure, and that in *Bos urus*, some species of *Macropus*, and various genera of monkeys a nail-like structure had been observed at the end of the tail.

A few years ago Dr J. E. T. Aitchison, now British Commissioner in the Punjab, read a paper before the Royal Medical Society of Edinburgh, in which he stated that a claw-like appendage was to be found at the tip of the tail in the large felines, but doubts were expressed at the time as to the accuracy of his statements. Dr Aitchison has however availed himself of the opportunities afforded by his residence in the Punjab to secure the tails of two leopards, which he forwarded for examination early in the present year to my colleague, the Professor of Natural History. Owing to the absence of Dr Wyville Thomson, in charge of the Deep Sea Exploring Expedition, the specimens have been handed over to me.

On turning on one side the hairs at the tip of the tail of one of the specimens, I found a grey-coloured, hard, hairless conical structure, which projected for $\frac{2}{10}$ths of an inch beyond the roots of the nearest circle of hairs. It terminated in a sharp, prickly point, and possessed a diameter at its base, of not more than $\frac{1}{10}$th inch. It exhibited two circular constrictions, which gave me at first sight the impression that it might be formed by very minute terminal caudal vertebræ, but this impression was not borne out by more careful observation.

In the second specimen, the hard structure only projected $\frac{1}{10}$th inch beyond the roots of the nearest circle of hairs, and was slightly broader at the base than in the first specimen. It did not end in a sharp point, but had the form of a rounded, hairless, nipple-like projection. In neither instance could the structure be seen until the hairs were turned on one side, although in both cases their hardness and slight projection enabled me to feel them without difficulty.

I soaked the latter specimen in water so as to soften it, to enable me to examine its connections. I then carefully cut away the hairs in its immediate neighbourhood, and experienced no difficulty in seeing that it was nothing more than the hairless termination of the integument at the end of the tail, which though hard and horny in the dried condition, was now soft and flexible, like the ordinary skin of the tail with which it was continuous.

I then scraped some soft whitish material off the surface, and examined it microscopically. It consisted of well-defined nucleated, and stratified squamous epidermal cells. A thin slice of the sub-epidermal tissue made perpendicularly to the surface, was then placed under the microscope. In it I recognised a number of small papillæ, having the structural characters and mode of arrangement of the papillæ of the cutis. There could be no doubt, from its structural characters, that the so-called claw or prickle at the end of the leopard's tail, as Leydig had already pointed out in the case of the lion, had the structure of skin, but instead of consisting, as in the lion, of a single large papilla, it possessed numerous small papillæ. Notwithstanding the poetical idea of its function as a sting, it is to be regarded therefore, not as a specially developed organ, but merely as a hairless part of the integument.

ON AN EDENTULOUS CONDITION OF THE SKULL OF THE GREY SEAL (*Halichoerus gryphus*). By PROFESSOR TURNER.

IN Vol. v. of this *Journal*, p. 270, I stated that specimens of the grey seal had recently been captured on the East coast of Scotland, and I referred to two young animals caught in the salmon nets near Montrose. Since those specimens were recorded, I have received the skull of another animal of that species from the same locality, which exhibited a remarkable defect in the development of the teeth.

The skull was from an animal about half-grown, and measured 8½ inches in length. The basi-cranial synchondroses were unossified, and the sutures between the bones of the face and those between the bones of the cranial vault were so loose, that many of the bones could, without much force, be separated from each other. No teeth were present in the upper jaw, except the pair of canines, which were well developed, projected $\frac{7}{10}$ths of an inch beyond their sockets, and occupied their usual position immediately behind the maxillo-premaxillary sutures. Similarly no alveoli existed in the upper jaw, except those in which the canine teeth were lodged.

There was a complete absence also of teeth and alveoli in the lower jaw except the pair of canines and the sockets in which they were lodged. Owing to the absence of teeth the dentary borders of both upper and lower jaws were much narrower than in a well formed cranium, and the vertical diameter of the horizontal ramus was appreciably smaller than in a normal jaw of the grey seal of the same size. The dentary borders of both jaws were studded with small foramina, which opened into canals apparently for the transmission of blood-vessels.

The Anatomical Museum of the University contains a skull of this species of seal of almost precisely the same dimensions, which originally formed a part of the Monro collection, but of which there is unfortunately no record of the locality whence it was obtained. In this skull the dentition is perfect; all the teeth project prominently from their sockets, and present the following formula—

$$\frac{5\ 1\ 3 \mid 3\ 1\ 5}{5\ 1\ 2 \mid 2\ 1\ 5}$$

It is clear therefore that the grey seal at this period of life has completed its permanent dentition, and that the peculiarity exhibited by the cranium I have described is due either to a non-development, or premature atrophy, of all the teeth of the permanent series, except the upper and lower canines. This edentulous cranium is not without interest in connection with the consideration of the zoological affinities of the Seals to the Cetacea.

ON THE PHYSIOLOGICAL ACTION OF LIGHT. No. I.

By JAMES DEWAR, Esq. and JOHN G. M^c^KENDRICK, M.D.,
of the University of Edinburgh[1].

IT is the object of this communication briefly to describe some of the results we have already obtained in an investigation into the Physiological Action of Light on which we are at present engaged. We have more especially directed our attention to the problem of the specific effect produced on the retina and optic nerve by the action of light. Numerous hypotheses have been made from time to time by physicists and physiologists; but up to the present date our knowledge of the subject is without any experimental foundation.

It is evident that, in accordance with the principle of the transference of energy now universally accepted, the action of light on the retina must produce an equivalent result, which may be expressed, for example, as heat, chemical action, or electro-motive power. It is well known that the electro-motive force of a piece of muscle is diminished when it is caused to contract by its normal stimulus, the nervous energy conveyed along the nerve supplying it; and similarly a nerve suffers a diminution of its normal electro-motive force during action. In the same manner the amount and variations of the electro-motive power of the optic nerve affected secondarily by the action of light on the retina are physical expressions of certain changes produced in the latter; or, in other words, are functions of the external exciting energy, which in this case is light. Considerations such as these led us to form the opinion that the problem of what effect, if any, the action of light has on the electro-motive force of the retina and optic nerve would require for its investigation very careful and refined experiment.

The enquiry naturally divided itself into two parts, first, to ascertain the electro-motive force of the retina and nerve; and second, to observe whether this was altered in amount by the action of light. With regard to the first of these questions,

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[1] Abstract of paper read before the Royal Society of Edinburgh, April 21, 1873.

Du Bois-Reymond found, while pursuing his great investigations into the electro-motive properties of living tissues, that every point of the external surface of the eyeball of a large Tench was positive to the artificial transverse section of the optic nerve, but negative to the longitudinal section. This he accomplished by the use of his well-known non-polarizable electrodes formed of troughs of zinc carefully amalgamated, containing a solution of neutral sulphate of zinc, and having cushions of Swedish filter paper and clay-guards, on which to rest the preparation. These electrodes were connected by him with a galvanometer, and the preparation was placed so that the eyeball, carefully freed from muscle, rested on the one clay-guard, while the transverse section of the optic nerve was in contact with the other. By following Du Bois-Reymond's method we have had no difficulty in obtaining a strong deflection from the eyes of various rabbits, a cat, a dog, a pigeon, a tortoise, numerous frogs, and a gold fish.

In the investigation of the next question, namely the effect of light on the electro-motive force, we found more difficulty. The method followed was to place the eyeball on the cushions in the manner above described, to note the deflection of the galvanometer needle, and then to observe whether or not any effect was produced on the impact of a beam of light, during its continuance, and on its removal. In a few of our earlier experiments we used Du Bois-Reymond's multiplying galvanometer, but finding the amount of deflection obtained was so small, that the effect of light could not be readily observed, we have latterly used Sir W. Thomson's exceedingly sensitive reflecting galvanometer, kindly lent us by Professor Tait. We met also with secondary difficulties, such as the dying of the nerve, the impossibility of maintaining an absolutely constant zero, and an absolutely constant amount of polarity, the effects of heat, &c.; but these difficulties we have overcome as far as possible by the most approved methods. The changes in polarity of the apparatus occurred slowly, and could not be mistaken for the changes produced by the action of light, which we found occurred suddenly and lasted a short period of time. It is also important to state that the deflections we observed do not at present profess to be absolute, but only relative values.

The effects of heat were carefully avoided by covering over the electrodes on which the eye under examination rested with a spherical shell of water, of at least an inch in thickness, by means of a properly constructed glass apparatus.

The result of our work at present is that we have been able to demonstrate that the action of light on the retina alters the amount of the electro-motive power to the extent of from three to seven per cent. of the total amount of the natural current. This is most readily seen by using the eye of the Frog. On placing the eye on the cushions, so that the eyeball rests on the one cushion and the transverse section of the nerve on the other, there is no difficulty in obtaining a deflection of between 300 and 400 degrees on the scale of our reflecting galvanometer. This deflection slowly decreases for a time, until it reaches a point where it is, for a space of half an hour or an hour, comparatively steady, in amount. We then find the eye to be remarkably sensitive to light. A flash of light, lasting the fraction of a second, a lighted match held at a distance of 4 or 5 feet, the light of a small gas jet suddenly turned on, coloured light produced by allowing light from a small gas-flame enclosed in a lantern, to pass through a globular glass jar (12 inches in diameter) filled with a solution of ammoniacal sulphate of copper or bichromate of potash, have all produced remarkable changes in the amount of the electro-motive power.

When a diffuse light is allowed to impinge on the eye of the frog, after it has arrived at a tolerably stable condition, the natural electro-motive power is in the first place increased, then diminished, during the continuance of light it is still slowly diminished to a point where it remains constant; and on the removal of light, there is a sudden increase of the electro-motive power nearly up to its original position. The alterations above referred to are variables depending on the quality and intensity of the light employed, the position of the eyeball on the cushions, and modifications in the vitality of the tissues.

Similar experiments made with the eye of warm-blooded animals, under the same conditions, have never given us an initial positive variation, as we have above detailed in the case of the frog, but always a negative variation. The after inductive effect on the withdrawal of light occurs in the same way.

A large number of experiments has been made with different portions of the spectrum, which all tend to shew that the greatest effect is produced by those parts of the spectrum that appear to consciousness to be the most luminous, namely, the yellow and the green.

Similarly, experiments made with light of varying intensity shew that the physical effects we have observed vary in such a manner as to correspond closely with the values that would result if the well-known law of Fechner was approximately true.

The success of these preliminary experiments leads us to believe that by the employment of proper appliances this method of research may be greatly extended, not only with regard to vision, but also to the other senses. We expect soon to be in a position to communicate quantitative results involving time as a variable element in the case of the action of light on the retina and optic nerve, and we also intend prosecuting similar observations on the terminal structures and nerves of the other organs of special sense.

ON THE PHYSIOLOGICAL ACTION OF LIGHT. No. II.

By JAMES DEWAR, Esq., and JOHN G. McKENDRICK M.D.[1]

IN continuing our experimental enquiry on the Physiological action of Light on the Eye, we have found it necessary to construct a true graphical representation of the variations of the electro-motive force occasioned by the impact and cessation of light. It is clear that to register minute galvanometrical alterations, the only plan that could be employed would be to photograph on a sensitive surface, covering a cylinder rapidly revolving on a horizontal axis, the alteration of position of the spot of light reflected from the mirror, just as continuous magnetic observations are registered. As the apparatus required to execute these observations is very complicated, and would

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[1] Abstract of paper read before the Royal Society of Edinburgh, May 5, 1873.

require much preliminary practice, we have in the mean time adopted a simpler method of registration. This plan is to note the position of the galvanometer at equal intervals of time, before, during, and after, the impact of light on the eye. In these observations we have used a seconds pendulum giving a loud beat. One observer reads aloud the galvanometer, the other marks every interval of two and a half seconds, registers the numbers obtained, and regulates the supply of light. A little practice in the method above described has enabled us to obtain very satisfactory results, agreeing very closely in different observations, and shewing in a decided way the salient points of the variation curve. Figures 1 and 2 represent two curves thus obtained shewing typical forms of light variation.

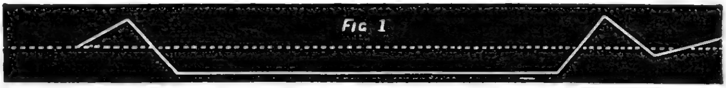
Fig. 1


Fig. 2

The central dotted line would represent the stable position of the electro-motive force in the dark. The curve above this line represents increase of the electro-motive force, while that below it is the reverse. The curve shewn in Fig. 1 represents the change observed when the cornea was in contact with the one cushion, and the transverse section of the nerve in contact with the other. On the other hand, the curve delineated in Fig. 2 is that obtained by placing the sclerotic instead of the cornea on the cushion, the transverse section of the nerve touching the other cushion. These curves shew that on the impact of light there is in Fig. 1 a sudden increase of the electro-motive force; during the continuance of light it falls to a minimum value; and on the withdrawal of light, there is what we have formerly styled an inductive effect, that is to say, a sudden increase of the electro-motive force which enables the nerve to acquire its normal energy. In other words, the falling off of electro-motive force, shewn in the diagram, is the physical representative of what, in physiological language, is called fatigue; the inductive effect exhibiting the return of the structure to its normal state. In the case of Fig. 2, the impact of light is followed by no increase. There is, however, a gradual rise during the continuance of light, and on the removal of light there is the inductive effect we have spoken of formerly.

We have carried out, since our last communication, four distinct sets of observations. *First,* as to the pigment-cells of the skin or choroid shewing any sensibility to light. It is well known there is no difficulty in obtaining a strong current from the skin of the frog, but we have not observed any sensibility to light. The same is the case with the pigment-cells of the choroid. *Second,* as to the action of different well-known poisonous substances on the sensibility of the retina. We have found that Woorara, Santonin, Belladonna, and Calabar Bean, did not seem to destroy the sensibility to light. *Third,* as to the action of the anterior portion of the eye. On carefully bisecting an eye of a frog, so as to remove completely the anterior portion including cornea, aqueous humour, iris, ciliary-muscle, and lens, and on bringing the retina into actual contact with one of the clay pads, we readily obtained a large deflection which was as sensitive to light as when the whole eye was employed, thus eliminating any possibility of the contraction of the iris under the stimulus of light having to do with the results previously obtained. On using the anterior portion of the eye so that the cornea and posterior surface of the crystalline lens were the poles, we obtained a large deflection, which was, however, insensible to light. The sclerotic and nerve without the retina, in the same manner, give a large natural electromotive force, also not sensitive. The distribution of the electromotive force between the different portions of the eye and cross section of the nerve may be stated as follows: The most positive structure is the cornea, then the sclerotic, then the longitudinal surface of the nerve; the cornea is also positive to the posterior surface of the crystalline lens, and the retina itself seems to be positive to the transverse section of the nerve. *Fourth,* as to the effect of varying luminous intensity on the electro-motive force. Perhaps the most remarkable result arrived at during the course of our experiments is the small difference between the amounts of alteration observed under conditions of varying luminous intensity. If a candle is placed at a distance of one foot from the eye, and then is removed ten feet, the amount of light received by the eye is exactly one hundredth part of what it got at a distance of one foot, whereas the electro-motive force, instead of being altered in the same proportion, is only reduced to one-third. Repeated experiments made with the eye in different positions has conclusively shown that a quantity of light one hundred times in excess of another quantity only modifies the electro-motive force to the extent of increasing it three times as much, certainly not more.

It was apparent to us that these experiments would ultimately bear upon the theory of sense-perception as connected with vision. It is now generally admitted that no image, as such, of an external object, is conveyed to the sensorium, but that in reality the brain receives certain impressions of alterations taking place in the receiving organ. The natural query then arises—are the physical effects we have described and measured really comparable in any way with our sensational differences in light perception when we eliminate all mental processes of association, &c., and leave only perception of difference of intensity? In other words, are these changes the representative of what is conveyed to the sensorium? It would appear, at first sight, that this problem is altogether beyond experimental enquiry. There is, however, a way of arriving at very accurate measures of the variation of our sensational differences in the case of light, and this has been developed theoretically and experimentally by the justly renowned physiologist Fechner. Stating the law of Fechner[1] generally, we may say, the difference of our sensations is proportional to the logarithm of the quotient of the respective luminous intensities. A recent series of experiments by Dalbœuf[2] has entirely confirmed the truth of this law. If, therefore, the observed differences in electro-motive power, registered under conditions of varying luminous intensity, agree with this law of Fechner, regulating our sensational impressions, then there can be little doubt these variations are the cause of, and are comparable to, our perception of sensational differences. Now, we have stated above, that

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[1] Fechner, *Elemente der Psychophysik.* Helmholtz, *Physiological Optics.*

[2] Recent Memoir to Belgian Academy.

with a quantity of light 100 times in excess of another quantity, the electro-motive force only becomes three times greater. According to Fechner's law, we may say the difference of our sensations, with that variation in the amount of luminous intensity, would be represented by 2, the logarithm of 100. Our experimental results being as 3 to 1, the difference is also 2, thus agreeing very closely. It is to be remembered, however, that these results have been obtained by experiment on the eye of the frog, but similar changes have been observed in the eyes of Mammals. In the latter, however, the amount of alteration is not so great, in all probability owing to the rapid death of the parts.

In order to see how far we could trace this alteration of electro-motive force in the course of the optic nerve, we have made some experiments without removing the eye from the orbit, leaving the nerve intact. On placing the cross section of the posterior part of the optic lobe on one cushion, and the cornea on the other, a variation, amounting to about one per cent. of the electro-motive force, could still be obtained.

Since the above results were communicated to the Royal Society of Edinburgh, we have made two experiments of some interest. In the first place, the same kind of results has been obtained by operating on the eye of the cat while it remained in the orbit of the living animal. Secondly, the eye of the frog has been experimented on with a beam of uncondensed moonlight and was found sensitive, thus eliminating all traces of radiant heat, as possible causes of the changes we have described.

CAUSE OF THE RETARDATION OF THE PULSE WHICH FOLLOWS ARTIFICIAL OR VOLUNTARY CLOSURE OF THE NOSTRILS IN THE RABBIT.

A reply to certain criticisms. By WILLIAM RUTHERFORD.
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IN 1868 I discovered that if chloroform, ether, amylic nitrite, acetic acid or ammonia be held before the nose of a rabbit, the heart's action soon becomes greatly retarded. I at first fancied that the inhibition of the heart in this case results from the inhalation of the vapour, but I soon abandoned this idea; for I found that when I opened the trachea, and placed a cannula in its lower end, and permitted the vapours to be inhaled through the cannula the *retardation of the heart did not occur*. I next supposed that the influence of the vapour might be owing to reflex action: viz. to an excitement of the cardio-inhibitory centre in the medulla following the local stimulation of nasal nerves. I observed, however, that when the vapour was presented to the nose of the animal, it *closed its nostrils* and ceased to breathe. During this, the inhibition of the heart appeared. And I further noticed that this retarded cardiac action ensued when the nostrils were *closed by the hand in the gentlest manner possible.* From these facts I suspected that the cardiac retardation was not owing to reflex action, but to stimulation of the cardio-inhibitory nerves by the state of the blood which results from arrest of the respiration; and this idea was confirmed by finding that closure of the nostrils by the hand, or the placing of chloroform, etc., before the nose did not retard the heart if the trachea had been previously opened, and the air prevented from passing through the nose by means of a cannula tied in the lower end of the trachea and having no communication with the upper end. I never published these experiments, but I alluded to the results in a paper on the "Influence of the Vagus upon the Vascular System," *Journ. of Anat. and Physiology,* Vol. III. I there (p. 408) stated that "the theory that the inhibitory influence of the vagus upon the heart is due to exhaustion of the cardiac ganglia produced by over-stimulation, seems to me irreconcilable with the following fact. If any irritating vapour, such as that of chloroform, ether, alcohol, acetic acid, etc., be held before the nose of a rabbit, it instantly closes its nostrils and ceases to breathe—often for 30 or 40 seconds. Within three seconds after the cessation of the respiration the heart comes almost to a standstill, and continues to beat very slowly until respiration be re-established. This arrest of the heart is due to stimulation of the inferior cardiac branch of the vagus by the asphyxiated condition of the blood, for the slowing of the heart does not set in if the vagi have been previously divided. The perfect calmness with which a rabbit will often sit with its heart almost stopped, seems to forbid the idea that in such a case the vagi are over-stimulated." By the term "inferior cardiac branch of the vagus" I simply meant the cardio-inhibitory fibres of the vagus, which in the rabbit are known to be contained in the inferior cardiac branch. My meaning was this—*the asphyxiated condition of the blood arrests the heart through the agency of the vagi, because the arrest of the heart does not appear if these nerves have been previously divided.* I *did not intend* anyone to suppose my meaning to be that the asphyxiated condition of the blood is the cause of the heart's arrest, because the heart is not arrested if the vagi have been previously divided. In the paper above mentioned I alluded to this matter in order to bring a new argument against Schiff's notion that the inhibition of the heart is due to exhaustion of the vagi.

Dr Brown-Séquard, in a paper on "The Sudden or Rapid Arrest of many Normal or Morbid Phenomena" (Brown-Séquard and Seguin's *Archives of Scientific and Practical Medicine,* New York, January, 1873), refers to this matter (p. 90). He states, that "*if the supposed asphyxiated condition of the blood* were the cause of the arrest of the heart, we should see the same effect from other causes of asphyxia, while the reverse is what we generally observe." And he further states, that the effect is *evidently due to a reflex influence proceeding from the nasal mucous membrane.* I trust that my distinguished friend will bear with me while I give the results of experiments which prove *his explanation to be untenable,* and mine to be, notwithstanding his strictures, the correct one. The experiments formerly performed by me were done without the aid of a kymograph; I have recently repeated them with the aid of this instrument, and I am satisfied with the perfectly accurate manner in which the following facts have been ascertained. I trust that my friend, and also other authorities[1], will repeat these experiments, and I shall be very glad to know whether after such repetition they still cling to such an explanation as that given by Brown-Séquard.

In the following experiments a mercurial kymograph (hæmodynamometer) was connected with an artery, and the pulsations recorded upon a Secretan's cylinder. At the same time a metronome and Neef's hammer were used to record seconds upon the paper on the cylinder. The seconds are indicated by dots on a straight line in the tracings (Figs. 1, 2 and 3). The interval between any pair of dots is not always of the same length, because the motion of even a Secretan's registering apparatus is not perfectly regular. The straight line upon which the dots occur is *not* an abscisse. It has nothing to do with the line indicating the zero pressure which is usually drawn on the paper in such experiments. The wavy line in the tracings indicates the heart's pulsations. Every wavelet is a pulsation. The risings and fallings of the wavy line indicate risings and fallings of the arterial blood-pressure. All the tracings are to be read from left to right.

Experiment I. *Rabbit.* Cannula of kymograph in lower end of right carotid artery.

No. of Observation.	Time.	Pulse in 2″	General Notes.
Obs. A	5.31′.51″	5	
	53	6	
	55	5	
	57	6	
	59	5	

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[1] See *Handbook for the Physiological Laboratory*, edited by Dr Burdon Sanderson, p. 274.

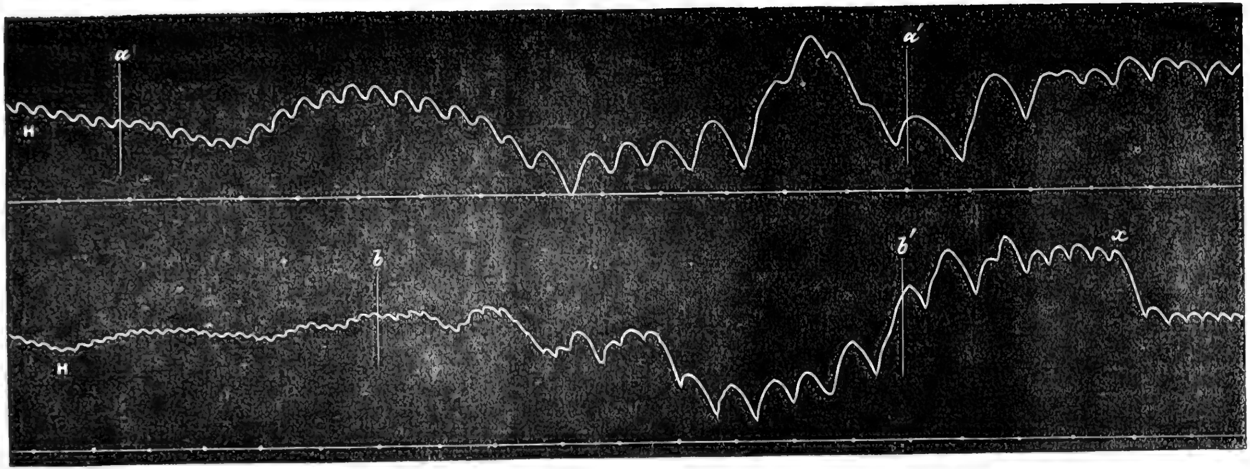
No. of Observation.	Time.	Pulse in 2′	General Notes.
Obs. A (*continued*).	5.32′.1″	6	During closure of the nostrils by the fingers the retardation of the heart was decided at the seventh second after the closure (which began at 5. 31′. 59″. *The graphic representation of this is given in Fig.* 1.
	3	5	
	5	5	
	7	3	
	9	3	
	11	3	
	13	3	
	15	5	
	17	5	
Obs. B	5.34′.48	8	
	50	7	
	52	7	
	54	8	
	56	8	
	58	7	
	35′.	8	
	2	7	The above was repeated. The closure of the nostrils began at 5. 35′. The retardation of the heart was decided at the *fourth* second after the arrest of respiration.
	4	6	
	6	6	
	8	5	
	10	4	
	12	4	
	14	3	
	16	3	
	18	2	
	20	3	
	22	4	
	24	6	
Obs. C	5.41′.58	8	
	42′.	7	
	2	7	A drop of strong ammonia held on paper before the nostrils. The animal immediately ceased to breathe. The retardation of the heart began at the *fifth* second.
	4	7	
	6	6	
	8	5	
	10	4	
	12	4	
	14	3	
Obs. D	5.54′.		The trachea was opened and a cannula was tied in its lower end.
	14	8	
	16	7	
	18	8	
	20	8	

No. of Observation.	Time.	Pulse in 2″	General Notes.
Obs. D (*continued*).	5.54′.22″	8	
	24	8	
	26	7	
	28	8	
	30	9	
	32	7	Nostrils were again closed by compression with the fingers. *The breathing continued (no retardation of heart).*
	34	8	
	36	8	
	38	6	
	40	8	
	42	7	
	44	7	
	46	7	
	48	7	
	50	7	
	52	7	
	54	7	
Obs. E	5.58′.32	8	
	34	8	
	36	8	
	38	9	
	40	8	
	42	8	
	44	8	A drop of strong ammonia placed on paper and held before nose. *The breathing continued, but at the same time became somewhat slower.* Observe that the heart's action was slightly retarded. Compare this with *Obs.* C.
	46	8	
	48	7	
	50	7	
	52	? struggle	
	54	?	
	56	?	
	58	7	
	5.59′.	6	
	2	7	
	4	7	
	6	6	
	8	6	
	10	7	
	12	6	
	54	8	
	56	8	
	58	8	
Obs. F	6.0′.0	8	

No. of Observation.	Time.	Pulse in 2″	General Notes.
Obs. F (*continued*).	6.0′.2″	7	*Obs.* E was repeated. The breathing continued, but became somewhat slower.
	4	8	
	6	7	
	8	7	
	10	6	
	12	6	
	14	6	
	16	? struggle	
	18	?	
	20	7	
	22	6	
	24	7	
Obs. G	6.4′.8	7	
	10	8	
	12	9	
	14	8	The nasal mucous membrane was pricked with the sharp points of a pair of scissors. The breathing was not arrested but the animal struggled violently.
	16	7	
	18	6	
	20	? struggle	
	22	?	
	24	?	
	26	8	
	28	8	
	30	9	
	32	9	
	34	9	
	36	9	
Obs. H	6.17′.2	8	During the whole of *Obs.* H, artificial respiration was kept up by means of Richardson's bellows attached to the cannula in the trachea in order to prevent deficient oxygenation of the blood.
	4	8	
	6	8	
	8	8	
	10	8	Ammonia held *before* the nose as in *Obs.* C and E. *No retardation of the pulse.*
	12	?	
	14	?	
	16	8	
	18	?	
	20	8	
	22	8	
	24	8	
	26	?	
	28	8	
	30	9	
	32	8	

No. of Observation.	Time.	Pulse in 2″	General Notes.
Obs. I	6.19′.52″	8	Artificial respiration still maintained during *Obs.* I.
	54	8	
	56	8	
	58	7	
	6.20′.	8*	At * a drop of *strong ammonia* was applied to the *mucous membrane of both nostrils*, and it was washed off at **. *No retardation of the pulse.*
	2	8	
	4	8	
	6	8	
	8	8	
	10	9	
	12	8	
	14	9	
	16	8	
	18	8	
	20	9	
	22	8	
	24	8	
	26	8	
	28	8	
	30	8	
	32	8	
	34	8**	
Obs. J	54	8	
	56	8	
	58	9	
	40′.	9	
	2	8	Respiration arrested by closing the cannula. *Pulse retarded.*
	4	8	
	6	7	
	8	5	
	10	6	
	12	3	
	14	4	

Fig. 1.



H the part of the trace first produced. Respiration arrested from *a* to *a′* by closing the nostrils. The consequent retardation of the pulse was *decided* at the *seventh* second after the arrest of the respiration. (See Experiment I. p. 286.)

Respiration arrested from *b* to *b′* by closing a cannula in the trachea. Distinct retardation of the pulse appeared at the *fourth* second after the arrest of the respiration. The high curves before *x* were produced by a struggle. (See Experiment II. p. 291.)

Experiment II. *Rabbit.* Cannula of kymograph in femoral artery.

No. of Observation.	Time.	Pulse in 5′	General Notes.
Obs. A	2.59′.13″	21	
	19	16	During arrest of respiration by closure of the nostrils by the hand.
Obs. B	3.0′.13	20	
	20	9	During arrest of respiration consequent upon holding a drop of strong ammonia on bibulous paper before the nostrils.
Obs. C			*Obs.* B was repeated with like results.
	3.18′.		Cannula placed in lower end of trachea.
Obs. D	3.20′.6	21	
	9		
	18	20	During closure of nostrils by the fingers. *Breathing was not arrested.*
	21		
	23′.12	20	
	13		
	21	20	Ammonia held on paper before nose. *Breathing not arrested. Pulse not retarded.*
	30	20	
	32		
		Pulse in 1″	
Obs. E	3.24′.9	5	See Fig. 1 (*b*) for a graphic representation of *Obs.* E.
	10	5	
	11	4	
	12	5	
	13	5	
	14	4	
	15	4	
	16	5	
	17	4	Respiration arrested by closure of cannula. Retardation of the heart decided at the fourth second.
	18	3	
	19	2	
		Pulse in 10″	
Obs. F	3.30′.14	45	
	21		
	36	32	Nasal mucous membrane pricked and scratched by means of a needle. There was slight struggling. *The respiration became slower.*
	48	40	
	49		

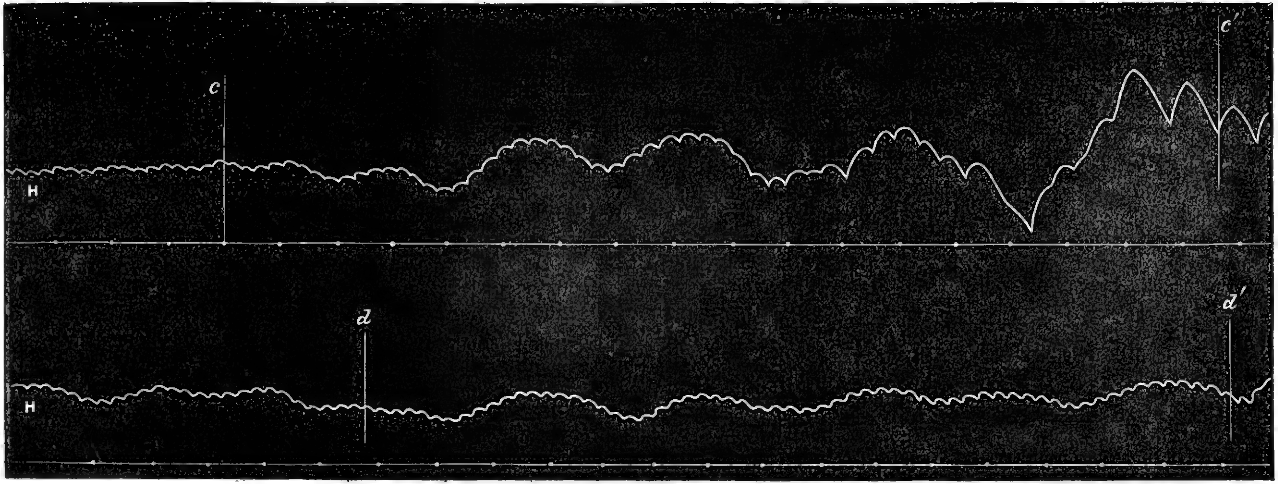
No. of Observation.	Time.	Pulse in 10″	General Notes.
Obs. G	3.37′.9″	44	Artificial respiration had recourse to in order to prevent deficient oxygenation of the blood.
	10 20 29	 42 Struggle	Nasal mucous membrane again pricked and scratched. During artificial respiration.
Obs. H	3.50′.4	Trace not sufficiently clear to show the pulse-rate.	
	8		A drop of strong ammonia applied to the nasal mucous membrane.
	17	43	
	29	44	
	38		Ammonia washed off. Artificial respiration was kept up during the whole of *Obs.* H. (Although the pulse could not be ascertained at 3 . 50′ . 4″ it may be safely said that in this Observation there was no *retardation* of the pulse.)
Obs. I	3.56′.9	42	
	14		Ammonia applied to nasal mucous membrane.
	34	40 or 42 ?	
	40		Ammonia washed off. Artificial respiration kept up all the while as in *Obs.* H. *No retardation.*

Experiment III. *Rabbit.* Cannula of kymograph in femoral artery.

No. of Observation.	Time.	Pulse.	General Notes.
		in 2″	
Obs. A	3.36′.18″	9	
	20	8	
	22	8	Respiration arrested by gently compressing the nostrils with the fingers. See Fig. 2 *c—c′* for a graphic representation of *Obs.* A.
	24	8	
	26	8	
	28	6	
	30	6	
	32	5	
	34	5	
	36	3	
	38		
Obs. B			A drop of strong ammonia upon bibulous paper was held before the nose. The animal shut its nostrils and the pulse was retarded as usual. The results are not given because the metronome apparatus failed to record the seconds on this occasion. The trachea was opened and a cannula placed in its lower end.
		in 10″	
Obs. C	3.57′.12	40	
	15		Nostrils closed by fingers. *Respiration still continued through the cannula.* (See Fig. 2 *d d′* for a graphic representation of *Obs.* C.)
	28	41	
	31		
Obs. D	4.3′.8	33	
	14		Ammonia held in front of nose as before. *Respiration continued through the cannula* unchanged. Notice that in *Obs.* C and D the pulse was *not* retarded.
	27	33	
	29		
Obs. E	4.6′.12	33	
	16		Mucous membrane of nostrils pricked and scratched with a needle. The *respiration became slow and feeble. Notice the retardation of the pulse.*
	27	25	
Obs. F	4.7′.6	30	

No. of Observation.	Time.	Pulse in 10″.	General Notes.
Obs. F (*continued*).	4.7′.11″		A drop of strong ammonia applied to mucous membrane of nostrils. *The respiration became feeble and slow*, and continued to be so until 4 . 7′. 35″ when the ammonia was washed off. Notice the retardation of pulse. (For a graphic representation of *Obs.* F, see Fig. 3 *e*.)
	21	27	
	31	24	
			Artificial respiration was now had recourse to in order to prevent deficient oxygenation of the blood during the irritation of the nasal mucous membrane.
Obs. G	4.10′.50	34	
	11′.		The mucous membrane of the nostrils was pricked as before. *No pulse retardation now.*
	12	35	
	14		
Obs. H	4.18′.14	40	
	19		Ammonia applied to mucous membrane of nostrils. *Slight pulse acceleration.*
	34	42	
	53	44	
	59		Ammonia washed off.
Obs. I	4.28′.24	40	
	35		Ammonia again applied to mucous membrane of nostrils. *No retardation of pulse.*
	52	41	
	54		Ammonia washed off. (See Fig. 3 *f* for a graphic representation of *Obs.* I.)

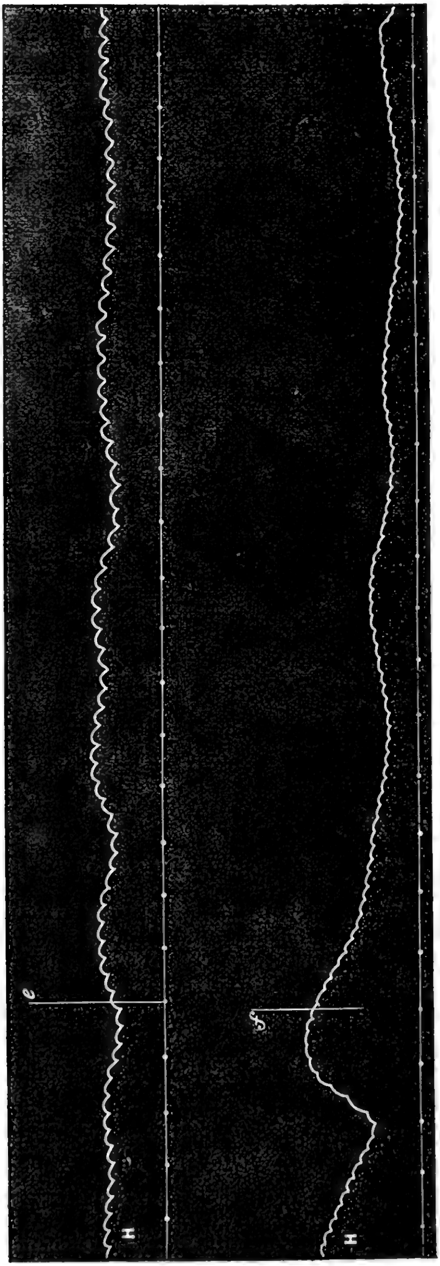
Fig. 2.



H, H the part of the trace first produced. Respiration arrested by closing the nostrils from *c* to *c′*. (See Experiment III. p. 293.) Distinct retardation of the pulse appeared at the *eighth* second after the arrest of the respiration.

Nostrils closed from *d* to *d′ during the continuance* of respiration through a cannula in the trachea. There was no retardation of the pulse. (See Experiment III. p. 293.)

Fig. 3.



H the part of the trace first produced. *e* a drop of ammonia applied to mucous membrane of nostrils. Enfeeblement of respiration and slight retardation of the pulse ensued. (See Experiment III. p. 294.)

f ammonia applied to the mucous membrane of the nostrils of the same rabbit during the maintenance *of artificial respiration.* No retardation of the pulse. (See p. 294.)

General Results of Experiments 1, 2 and 3. 1. If the nostrils of a rabbit be closed by the fingers, and the breathing be thereby arrested, retardation of the pulse speedily ensues. The time at which the retardation appears varies; it may be as early as the *fourth* second after the closure (see *Obs.* B, Exp. 1, and *Obs.* E, Exp. 2), but it frequently begins a few seconds later than this[1].

2. *The retardation of the pulse does not follow the grasping and closure of the nostrils if the respiration be permitted to continue through a fistula in the trachea.*

3. When a piece of bibulous paper containing ammonia is held before the nose, the animal *closes its nostrils and ceases to breathe for a time. The closure of the nostrils protects the* mucous membrane from irritation by the pungent vapour, but notwithstanding this the pulse is retarded.

4. When the trachea is opened and a cannula placed in its lower end, retardation of the pulse follows closure of the *cannula as speedily as* it follows arrest of the *respiration by closure of the nostrils.* In the former case the local mechanical stimulation of nerves such as those of the nostrils is out of the question.

5. It follows from 1, 2, 3 and 4 that the retardation of the pulse consequent upon closure of the nostrils, and upon the holding of bibulous paper with ammonia before the nostrils, is *due to the arrest of the respiration.*

6. The *state of the blood* resulting from the arrested respiration is the cause of the retardation of the pulse, and it retards the heart by acting upon the cardio-inhibitory nerve apparatus; because if the cardio-inhibitory nerves be paralysed by atropia the retardation of the pulse does not follow the arrested respiration until death sets in. The cardio-inhibitory centre in the medulla is, in all probability, *mediately* or *immediately* thrown into opera-

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[1] In my former paper, loc. cit., I stated "that within *three* seconds after the cessation of respiration the heart comes almost to a standstill, and continues to beat very slowly until respiration be re-established." The more accurate and graphic method leads me now to put it thus: "Sometimes at the fourth second after the cessation of respiration distinct retardation of the pulse may set in."

tion by this state of the blood (deficient oxygen or accumulated carbonic acid?), because the retardation of the pulse is not observed if the vagi have been divided in the neck previous to the arrest of the respiration. (The facts here given (No. 6) were ascertained by me six years ago.)

7. The opinion expressed by me in my previous paper (loc. cit.) regarding the cause of the retardation of the pulse *receives from these experiments an absolute confirmation.*

8. Irritation of the mucous membrane of the nostrils of the rabbit, by pricking or scratching, or by the application of ammonia (liquor ammoniae fortissimus), is usually (but not always) followed by retardation of the pulse, even when the respiration continues through a tracheal fistula. The cause of this is probably to be found in the fact that during the nasal irritation the respiration usually becomes feeble and slow. And this idea is confirmed by the fact that if the blood be kept fully oxygenated by artificial respiration the pulse is not retarded during the nasal irritation.

9. Although the application of ammonia to the nasal mucous membrane during the maintenance of a thorough artificial respiration does not retard the pulse, nevertheless, I twice observed (*Obs.* H and I, Exp. 3) that when artificial respiration was stopped, and the ammonia washed off, *that retardation of the pulse appeared* and continued for some seconds. Was this owing to retardation of respiration, or could it be due to stimulation of the cardio-inhibitory mechanism reflexly from the nose? Might it not be that the hyperoxygenated condition of the blood diminished the excitability of the cardio-inhibitory apparatus—thereby preventing the nasal irritant from affecting the heart during the artificial respiration?

In order to determine this point I divided the vagi of a rabbit in the neck—observed the extent of the retardation of the heart's action that resulted when the lower end of the vagus was faradised by a current derived from Du Bois-Reymond's machine (2d. 120 mm. distant from 1st coil, one small Grove). I then established artificial respiration by means of Richardson's pump and a tube in the trachea (as I had done in the previous experiments). I stimulated the lower end of the same vagus with a current of the same strength as before, and the result showed that the condition of the blood produced by this mode of respiration did not diminish the excitability of the cardio-inhibitory mechanism below the level of the middle of the neck, and the fact that in experiments 2 and 3 the adoption of artificial respiration with the vagi undivided did not accelerate the heart's action, leads me to conclude that the activity of the cardio-inhibitory apparatus in the medulla is not diminished by such respiration; for, were it so, the heart's action would be accelerated as it is when the cardio-inhibitory nerves are paralysed by division or otherwise. I therefore conclude that the pulse retardation observed in *Obs.* H and I, Exp. 3, to which allusion has just been made, was probably the result of *diminished respiration* resulting from the excitement of the nasal mucous membrane.

NOTES OF SOME CASES OF ABNORMAL ARRANGEMENT OF THE ARTERIES OF THE UPPER EXTREMITY. By J. J. CHARLES, M.A., M.D., &c., *Demonstrator of Anatomy, Queen's College, Belfast.*

1. *Vas aberrans, joining the ulnar artery.* A rare variety of *vas aberrans* was discovered last month in the Anatomical Rooms of Queen's College, Belfast, during the dissection of the body of a female, aged 30 years. In the right arm a slender artery, five inches and a half long, arose from the brachial artery, a little below the middle of the humerus, and two inches below the lower border of the teres major muscle, and accompanied the brachial on its inner side to the neck of the radius, where it joined the ulnar a quarter of an inch from its origin. It was pervious throughout, being filled with injection like the brachial, but it gave off no branches. The brachial, radial, and ulnar arteries were normal as to their position and number of branches, except that the anastomatic which should arise from the brachial was absent.

In the left upper extremity the arteries had a normal arrangement.

Quain, even in his large experience, speaks of having met with only nine instances of *vasa aberrantia*, and these all ended in the radial except one which joined the radial recurrent, but it was in that case a branch of the ulnar. He states, however, that Monro and Meckel had each observed a single instance in which the *vas aberrans* terminated in the ulnar directly[1]. Cruveilhier has, on two occasions, seen a *vas aberrans* joining the ulnar[2].

2. *High origin of the radial artery;* and *vas aberrans joining the radial artery.* It is a curious coincidence that last month there were, in the Belfast Anatomical Rooms, five upper

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[1] *The Anatomy of the Arteries of the Human Body*, pp. 265 and 266; 1844: 131; 1871.

[2] *Traité D'Anatomie Descriptive;* 4° Edition; Tome 3°, p. 131, 1871. Wenzel Gruber observed in 600 bodies examined *vasa aberrantia* joining the radial artery in five arms, and in one case only did a *vas aberrans* join the ulnar artery. (Eds.)

extremities in which the radial artery had a high origin. In the first, the radial arose in the upper third of the arm, close to the head of the humerus; in the next three it took origin in the middle third of the arm; and in the fifth it arose in the lower third, and was joined about an inch from its origin by a *vas aberrans* which was four inches and a half long, and had sprung from the inner side of the brachial about half an inch below the lower border of the teres major. In all these cases the radial arose from the *inner* side of the axillary or brachial, and lay superficial to the pronator radii teres, except in one instance where it passed between the two heads of origin of that muscle.

It will be remarked that I have referred above to six cases of abnormal arrangement of the arteries of the upper extremity which occurred in five bodies. One was a case of *vas aberrans* joining the ulnar, in the right arm; the remaining five were instances of high origin of the radial—four in the right and one in the left arm. In only one body was the disposition of vessels abnormal in both arms; and in that body, on the right side, the radial arose from the axillary, and, on the left, from the lower third of the brachial, but it was afterwards joined by a *vas aberrans* an inch below its origin. This arrangement of arteries in the two arms supports the view of Bichat and Quain in opposition to Meckel who held that "lateral symmetry, the most powerful of all (kinds of symmetry) is maintained even in malformations[1]."

P.S. Most of the specimens referred to above were exhibited at the Ulster Medical Society, March 15.

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[1] Quoted by Quain in his *Anatomy of the Arteries of the Human Body*, p. 265.

ON THE PLACENTATION OF THE SLOTHS.

By Professor TURNER.

(Abstract of a Memoir communicated to the Royal Society of Edinburgh, May 19, 1873.)

AFTER referring to the paucity of information on the placental characters of the Sloths, and to the various inferences which had been drawn by anatomists from Carus's figure of the placenta of *Bradypus tridactylus*, some holding that it was cotyledonary and non-deciduate, others that it might have intermingled with it maternal deciduous substance, the author proceeded to describe his dissection of the perfectly fresh gravid uterus of a specimen of a 2-toed Sloth. This specimen only possessed 6 cervical vertebræ, and was referred to the *Cholæpus Hoffmanni* of Peters. The author had succeeded in obtaining excellent injections both of the fœtal and maternal systems of blood-vessels. The placenta consisted of about thirty discoid lobes, aggregated together, and occupying about four-fifths of the surface of the ovum. These lobes could be peeled off the placental area of the uterus, and carried away with them a layer of deciduous serotina, curling arteries, utero-placental veins, and a very remarkable system of intra-placental maternal sinuses, continuous with the uterine vessels, freely anastomosing with each other within the substance of the lobes, and lying between and in contact with the fœtal villi. Definite walls, distinct from the walls of the fœtal villi, could be traced around the sinuses. Crowds of red blood-corpuscles were situated within the sinuses, and it was observed that many of these seemed to be nucleated, an appearance which had been recognised a few years ago by Kühne, Rolleston and Moseley, in the blood-corpuscles of the Tardigrada. This sinus system possessed a special interest, because it presented a gradation between the capillary net-work of the uterine mucous membrane occurring in the diffused placenta of the mare or the cetacean, and the freely anastomosing cavernous maternal blood-spaces seen in the highly concentrated human placenta. The amnion lay in contact with the inner surface of the chorion as in the human fœtal membranes; its inner surface was smooth and serous, but there was no liquor amnii. The fœtus possessed a very remarkable special envelope like that figured and described by Welcker as investing the fœtus of *B. tridactylus* and a few other mammals, which envelope he has named an Epitrichium. Numerous additional details respecting the structure of the placenta and membranes are contained in the memoir.

The conclusions drawn from the examination of this placenta were: that in the Sloths the placenta is not cotyledonary and non-deciduate as in the Ruminants, but in the fullest sense of the word deciduate. If the inference drawn by Huxley from Sharpey's observations on the structure of the placenta of *Manis* be correct, then, if the placental system of classification is to be of any value, the non-deciduate scaly Ant-eaters can no longer be grouped along with the deciduate Sloths in the order Edentata, which order will have therefore to be subdivided. The author then compared the placentation of the Sloths with that of the other deciduate mammals, and pointed out a series of very interesting affinities between its placenta and that in the Primates.

NOTES OF SOME IRREGULARITIES IN MUSCLES AND NERVES. By JOHN CURNOW, M.D., *London; Demonstrator of Anatomy in King's College, London.*

IN this paper I have recorded only the less frequent irregularities in muscles and nerves that have come under my observation, and of many of them I have failed to find any mention, although from the extensive and scattered literature of the subject, I may have overlooked references thereto. I have arranged them in anatomical order, taking the muscles first.

1. *External Rectus.* In addition to the usual muscles, two extra slips were found in the right orbit of a female subject. They were apparently differentiations of the external rectus, and arose with its lower head from the ligament of Zinn. The inner and shorter slip was inserted into the outer half of the cartilage of the lower eyelid, where it joined the larger and more external slip, which was inserted into the periosteum of the outer wall of the orbit as well as into the cartilage. This slip was almost as broad as the external rectus itself, and was supplied by a branch of the sixth nerve equal in size to that supplying the external rectus. Both slips passed forwards directly beneath the lachrymal gland. Their use is very obscure, for although the inner one would slightly retract the lower lid, the outer and larger one was chiefly attached to the periosteum. I am unaware of any observations that would throw light on them from a morphological standpoint.

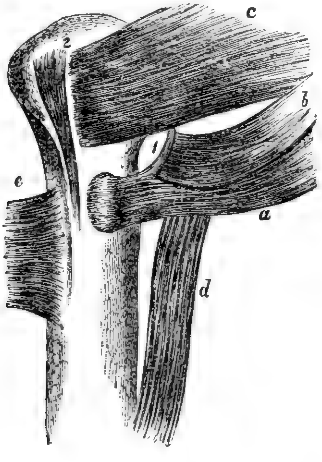
2. *Complexus.* On both sides a small band of muscular fibres arose from the ligamentum nuchæ at the third cervical spine, in connection with the upper fibres of the splenius capitis, and ran upwards parallel to the ligament nuchæ to just below the superior curved line of the occipital bone. A few of the fibres also arose from the upper inch and half of the ligament. It was separated from the complexus by a distinct cellular interval, and overlapped the innermost fibres of that muscle.

3. Several anomalies were noticed among the muscles passing from the neck to the trunk and shoulder. Besides a typical example of the rhombo-atloid of Macalister, and less developed specimens extending to the scapula and the fascia over the serratus posticus superior from the lower cervical vertebræ and the fascia over the splenii, two rarer variations occurred. A small slip from the posterior tubercle of the transverse process of the third cervical vertebra passed downwards across the posterior triangle in front of the levator anguli scapulæ to join the first digitation of the serratus magnus. The levator anguli scapulæ arose by three digitations from the first, second, and fourth vertebræ, and missed the third, where its position was exactly occupied by this abnormal slip. A precisely similar muscle is mentioned in the Guy's Hospital Reports for 1871, and Rosenmüller described a slip from the transverse process of the atlas to the serratus

magnus. In another subject a small muscle arising from the third cervical vertebra, between the tendons of the levator anguli scapulæ and the scalenus medius, passed downwards behind the latter muscle, and then turned forwards to be inserted by a bifurcated tendon into the first and second ribs just behind the attachments of the serratus magnus. Although somewhat resembling some of the additional scalene muscles described by Albinus, Sömmering, Meckel, and Macalister, this should be classed among the imperfect varieties of the levator claviculæ, whose signification has been pointed out so completely by Prof. Wood. (*Phil. Trans.* 1870.) The other slip is one of the transitional forms between the levator claviculæ and occipito-scapularis.

4. *Sterno-scapular or Sterno-chondro-scapular.* (Wood.) This was a well-developed specimen of the muscle so variously described by anatomists as an anomaly of the subclavius, omo-hyoid, and even serratus magnus. It arose with the subclavius from the first costal cartilage, and passed backwards to the supra-scapular ligament and base of the coracoid process, joining the origin of the omo-hyoid.

5. In a spare female, on the right side only, the tendons of the latissimus dorsi and teres major had this curious arrangement at their insertion (see Fig.). The latissimus dorsi (*a*) did not extend so far outwards as the base of the bicipital groove, but was attached to a prominent tubercle, three quarters of an inch long, just internal to its inner lip. The muscular fibres ceased just as the long tendon of the triceps (*d*) passed behind it, and from this point a tendinous band (1) ran upwards in front of the triceps tendon to the axillary margin of the scapula. The teres major (*b*), muscular throughout, did not reach the humerus, but was inserted into the band just described, and into the long head of the triceps. The insertion of the sub-scapularis (*c*) was very large, contrasting markedly with the other tendons. Besides these anomalies, a small muscle (2) which could act



as a tensor of the capsular ligament was present. It arose from a special groove between the inner lip of the bicipital groove and the tubercle for the latissimus, and was lost on the anterior and inner part of the capsular ligament, near the insertion of the sub-scapularis. I can find no reference to this muscle, or to a similarly aborted insertion of the teres major.

6. *Biceps and Coraco-brachialis.* In a very muscular male, the right biceps was very complex both at its origin and insertion. In addition to long, short, and humeral heads, there was an extra coracoid head, with a few fibres joining it from the capsular and coraco-acromial ligaments. It passed downwards and joined the humeral head at the junction of the middle and lower thirds of the humerus, instead of blending with the normal coracoid as is usually the case. The muscle was mainly inserted into the semilunar fascia and the tubercle of the radius, but it gave off from its inner side a tendinous slip which split into three parts, (*a*) to condyloid origin of pronator teres; (*b*) a slip giving origin to the fibres of that muscle which usually arise from the coronoid process, and separated from the former by the median nerve; (*c*) to upper part of radial origin of flexor sublimis digitorum.

In the same arm was a well-developed chondro-epitrochlearis, and an aberrant slip of the coraco-brachialis, as described by Struthers. This arose from the capsular ligament, lesser tuberosity, and upper part of the latissimus dorsi tendon, and crossing the brachial vessels joined the coraco-brachialis, which was pierced by the musculo-cutaneous nerve as usual. On the left side, the only peculiarity was a biceps, with a third head from its common position on the humerus.

7. *Flexor Sublimis Digitorum.* A remarkably thin tendon for the little finger was given off from the *radial* side of the tendon to the ring finger, and crossed the latter superficially to its usual position.

8. *Flexor Carpi Ulnaris.* From its usual insertion a tendinous prolongation passed forwards under the abductor minimi digiti, and was lost in the ligaments around the metacarpo-phalangeal joint of the little finger. I have seen only one specimen of this slip, and I can find no mention of it, so that in regard to frequency there is a marked contrast between it and the prolongation of the extensor carpi ulnaris or ulnaris quinti, which occurs in as many as 12 per cent. of subjects. (Wood.)

9. *Extensores Carpi Radiales.* Besides the normal radial extensors of the carpus, a third was present, and equalled either of the others in size. It arose by two fleshy bellies from the adjacent sides of the radial extensors—that from the brevior being the larger—and about 2 inches from the lower end of the radius formed a single tendon, which was inserted into the ulnar side of the index metacarpal bone. The longior and brevior were inserted as usual. It differed from the extensor carpi radialis intermedius of Wood, which consists of a cross slip or slips between the two radial extensors, and also from the extensor carpi radialis accessorius, which is inserted into the

base of the first metacarpal. An exactly similar muscle is described by my late colleague Mr Perrin in the *Medical Times and Gazette*, 1872, Vol. II.

10. *Extensor Quarti Digiti vel Annularis.* In the left arm of a male subject, in addition to the common extensor tendon, a special extensor of the ring finger was found. It arose from the posterior surface of the ulna for three inches to the inner side of the origins of the extensor secundi internodii pollicis and extensor indicis. It continued fleshy to annular ligament, and having passed through the common extensor groove joined the ulnar side of the extensor aponeurosis on the back of the ring-finger. The indicator and extensor minimi digiti were normal. The extra tendons to this digit previously noticed, have been of two kinds, viz.: differentiations of the extensor minimi digiti as in most quadrumana which occur as often as thirteen times in 102 subjects (Wood); or more or less abortive specimens of the extensor brevis digitorum manûs, arising from the lower end of the radius, the carpus, or metacarpus. Some examples of both these varieties were found, but the muscle just described differed essentially therefrom, being quite as distinct and special to the ring-finger as is the extensor indicis to the fore-finger, which it much resembled in size and appearance.

11. *Extensor Carpi Ulnaris.* This was once found double throughout, but both tendons were inserted into the fifth metacarpal bone. No ulnaris quinti present. Extensor minimi digiti also double.

12. *Psoas.* Besides the normal psoas magnus, a muscle arose by two origins; an upper from the first lumbar vertebra, and a lower from a tendinous arch attached to the fourth intervertebral substance and the margins of the adjacent vertebræ. It passed under Poupart's ligament, and was inserted into the capsule of the hip-joint, and into the femur just above the lesser trochanter. This seems rather a differentiation of the psoas magnus than a true psoas parvus. On the opposite side the psoas magnus was normal, and the psoas parvus absent.

13. In the left leg of a female subject a thin, penniform muscle arose from the posterior surface of the fibula, between the origins of the flexor longus hallucis and peroneus brevis, extending from the fibular origin of the soleus, to about 1 inch from the ankle-joint. It ran with the flexor longus hallucis, grooved the tibia, astragalus, and sustentaculum tali, and was inserted into the os calcis slightly anterior to that process, being covered by the inner head of the flexor accessorius. Most of the anomalous muscles in this situation are varieties of the peronei (peroneus quartus, Otto, &c.), and are inserted into the *outer* surface of the os calcis, cuboid, or fifth metatarsal bone; but a similar muscle is described in the Guy's Hospital Reports for the present year as connected with the flexor longus hallucis. This muscle is probably the homotype of the radio-carpus of Fano, occasionally seen in the upper extremity. In the same leg, beside the usual three peronei, there were found a small peroneus quinti, a tendinous extensor ossis metatarsi hallucis given off from the extensor proprius, and a well-developed extensor primi internodii arising from the fibula for 2 inches below that muscle.

14. In the left sole of a male subject a singular arrangement of the flexor tendons of the little toe was found. The flexor brevis digitorum was inserted into the sides of the *proximal* phalanx, after having been perforated by a tendon from the flexor accessorius as well as by the tendon of the long flexor. The tendon of the accessorius was inserted into the sides of the *middle* phalanx, having also been perforated by the long flexor tendon, which passed on to the *distal* phalanx. Absence of one or both of the tendons to the little toe have been frequently noticed, but I can find no instance of a special flexor to each phalanx from the three flexor muscles respectively.

II. NERVE-IRREGULARITIES.

Inferior Maxillary Nerve. The left foramen ovale was divided into two by a plate of bone running obliquely downwards and forwards. This plate was a quarter-of-an-inch wide in the middle, and a little wider at the ends. Through the lower and posterior division passed the sensory portion of the third division of the 5th nerve, with separate branches to the external and internal pterygoid muscles; the former in front, and the latter behind. Through the upper and anterior division passed the masseteric, deep temporal and buccal branches, and a second nerve to the external pterygoid. The small meningeal artery was absent. This division of the foramen ovale into two, is unnoticed in our English text-books, and Sömmering describes it as rare. Although present in many skulls, I am not aware of its having been noticed in the recent subject, and the relative positions of the structures as they passed through described. Although this must be quite fortuitous, it is interesting to notice that the buccal branch came through the upper foramen with the chief motor nerves.

In one case the gustatory or lingual nerve, after its junction with the chorda tympani, gave off several small branches to the origins of the superior constrictor and buccinator muscles from the pterygo-maxillary ligament. I could not, however, definitely make out whether they were distributed to those muscles, or passed through them to the mucous membrane.

The inferior dental nerve was divided into two parts by the internal maxillary artery as it passed forwards between the pterygoid muscles, and the mylo-hyoid nerve arose by a separate branch from each division. In one case the fission of the nerve was complete from its origin to its entrance into the dental canal, but there the two parts joined. In another subject, the left mylo-hyoid arose by two branches; one from the motor portion of the inferior maxillary trunk, and the other from the deep surface of the inferior dental nerve. It gave a branch to the superficial portion of the submaxillary gland, as well as its usual branches to the mylo-hyoid and digastric muscles.

Inferior Laryngeal Nerve. The right inferior laryngeal has been often seen to pass directly inwards to the larynx, instead of turning round the subclavian artery. In these cases, as pointed out by Hart, Reid, Demarquay, Turner and Krause, the right subclavian arises from the left side of the aortic arch. In one case Turner saw it wind round the inferior thyroid artery, and in the case I saw, it did the same, although that artery had an abnormal origin from the common carotid.

Spinal Accessory Nerve. In one subject on both sides the external branch of this nerve stopped at the sterno-mastoid muscle, while the trapezius was supplied by two branches from the third and fourth cervical nerves. In another instance, it divided into two branches, by far the larger one entered the sterno-mastoid, and the smaller twig ran across the muscle superficially to its posterior border, and there joined a branch from the second cervical nerve, which with another branch from the fourth supplied the trapezius. These two cases tend to show that probably the trapezius is wholly supplied by the spinal portion of the accessory nerve; for in the first, no fibres from the medulla oblongata, and in the second but very few, could have entered that muscle.

Phrenic Nerve. Besides the more frequent varieties in its origin, it was once joined by a large branch from the middle cervical ganglion. In another case it supplied the anterior scalenus muscle, and then divided into two branches between which the internal mammary artery passed. I have also noticed it divide into two branches immediately after its origin from the fourth cervical nerve (the outer of which was joined by the communicating twig from the nerve to the subclavius) and re-unite in the upper part of the thorax.

Posterior Thoracic Nerve. The serratus magnus was not unfrequently supplied by two nerves, a separate branch from the fifth cervical nerve going to its first digitation. In one case this differentiation was carried still further; for besides this branch to the first digitation, a second was supplied from the fifth nerve to the second and third digitations, while a third branch, wholly derived from the sixth nerve, was distributed to the remainder of the muscle.

Median Nerve. A small communicating branch between the outer and inner heads crossed the axillary artery under the pectoralis minor; the heads united in the middle of the upper arm, and the nerve then passed behind the brachial artery. In another subject the median arose by three heads; the third head was given off from an additional origin of the ulnar nerve from the outer cord of the brachial plexus crossing the axillary artery.

Ulnar Nerve. In one case in which the ulnar nerve arose from the outer and inner cords as described by Turner in Vol. VI. of this *Journal*, it supplied both sides of the middle, and the radial side of the ring finger on their dorsal surfaces, in addition to its usual distribution. In another case in which the ulnar arose as usual, it supplied the contiguous sides of the ring and middle fingers instead of the radial.

Internal Cutaneous Nerve. From the loop between the two anterior thoracic nerves a small twig ran down the front of the upper arm, and becoming cutaneous in the lower third, passed over the median basilic vein and thus took the place of the superficial branch of the internal cutaneous nerve, which altogether passed under the vein, and became cutaneous at the bend of the elbow.

Lumbar Plexus. Besides the more usual varieties in the arrangement of the branches from this plexus, in one dissection the following nerves were all given off separately, presenting a most complex arrangement. Ilio-hypogastric, ilio-inguinal, genital branch of genito-crural, crural branch of genito-crural, anterior and posterior divisions of external cutaneous, branch to iliacus, small branches to psoas, anterior crural, middle cutaneous dividing into two branches before passing under Poupart's ligament, obturator, and accessory obturator. A more complete differentiation of the branches derived from the plexus could scarcely be imagined. I regret that my attention was called to the dissection too late to accurately make out from which nerve of the plexus each branch was derived.

I must express my great obligations in the compilation of this paper to Prof. Macalister's catalogue of muscular anomalies, to the various memoirs of Prof. Wood on the same subject, to the monograph of Krause and Telgmann, and the papers of Prof. Turner on nerve irregularities.

CASE OF CONGENITAL ABSENCE OF THE QUADRICEPS EXTENSOR CRURIS MUSCLE. Communicated by Prof. A. G. DRACHMANN, of Copenhagen[1].

MISS A. F., aged 28 years, consulted me in November of last year (1871), for an affection of the left knee, from which she stated she had suffered for a very long time—how long she could not remember, but it had increased of late years, and rendered walking more and more difficult, while she also usually felt pains in the knee-joint, especially when she at all exceeded her ordinary amount of walking. The knee-joint, too, became tender and swollen—a condition which, however, gradually disappeared if she remained at rest for any length of time. On examining the uncovered knee I was not a little surprised to find the knee-cap wanting; the outlines of both condyles of the femur very perceptibly exposed, covered only by the skin and some subcutaneous areolar tissue; the anterior inter-condyloid fossa similarly covered only by skin and filled with a rather soft, subcutaneous adipose tissue, which however was not present in such amount as to completely fill up the whole depression between the condyles, but left a visible sulcus behind. No trace of the ligamentum patellæ existed; but the tuberosity of the tibia, and the outlines of the condyles of this bone were seen and felt very plainly immediately beneath

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[1] Translated from the *Nordiskt Medicinskt Arkiv*, Vol. IV., Part I. 1872, by J. W. Moore, M.D., M.Ch. Dub.; Hon. Fell. Swedish Soc. Phys.

the skin. The whole anterior aspect of the thigh, from its upper third down to the knee, had lost its usual roundness and fulness. The thigh-bone itself throughout this space was felt immediately underneath the skin, without a trace of intervening muscular substance. A little above the external condyle of the femur, on the outer aspect of the thigh, the atrophied patella was found lying, without any attachment to any of the femoral muscles, freely moveable in all directions. The skin over the knee-joint was perfectly normal, no swelling of the tissues constituting or surrounding the articulation was present, no effusion into the *capsule of the knee.* On rather deep pressure being made over and a little above the external condyle, the patient felt some tenderness. The knee-joint freely admitted of passive motion; as regards active motion, the patient could easily bend the knee, but she could by no means extend it, nor was she able, while in the recumbent position, to lift the limb. The muscular structures on the posterior aspect of the thigh, and in the upper third of its inner aspect (the adductors) were strongly developed, while the triceps cruris (adductores longus, brevis, et magnus) was found more than ordinarily strong and largely developed. Measurement round the upper third of the thigh gave 18 inches, above the knee 10½ inches, round the leg 12½ inches. On bidding her strip the other, the right knee, of which she did not complain, I discovered to my surprise, that even in the most minute particulars it corresponded perfectly to the left one. On more closely interrogating the patient, I learned that she had not been aware of any defect in connection with her knees until her tenth year, although her gait had presented some irregularity. This had not however prevented her from playing and running about with her playfellows. She further stated that at this time she fell and hurt her knees, which a medical man had examined and had then declared that she suffered from a congenital and incurable defect. Since that time she has constantly, as the physician advised, worn a bandage on her knees, the result of which has been (as she positively affirmed) that the patella, which was before situated over the internal condyle of the femur, had by degrees glided over to the other, the opposite side, where it is now situated. It is only within the past two years, since she has been obliged to walk and stand a good deal (she is teacher in a large national school), that the inconveniences in walking and the troubles above mentioned have become more pronounced, and, as stated, have extended as yet only to the left lower extremity.

REVIEWS AND NOTICES OF BOOKS.

Principles of Animal Mechanics. By the Rev. S. HAUGHTON, F.R.S., Fellow of Trin. Coll., Dublin. London, Longmans, 8vo. pp. xix. 495.

ALL those who are interested in the application of the exact methods of mathematical and mechanical science to physiological problems, will turn eagerly to a work on animal mechanics by the accomplished mathematician who fills the chair of Geology at Dublin. And there is a large portion of the book with which they will not be disappointed. The important section from p. 164 to p. 361 is occupied with a classification of the muscles according to the arrangement of their fibres, and a discussion of their action; and in the next eighty pages the results previously obtained are applied to the discussion of the mechanics of various important joints, particularly the shoulder and hip-joints of the larger *felidæ,* and to the arrangement of the muscular fibres of the heart. I shall have to remark hereafter on one or two special points in these sections; but, as far as I am aware, the subject has never before been handled with anything like the same completeness and thoroughness; and this portion of the book will well repay the labour of careful study, though there is little in it suitable for extraction or analysis here.

The earlier portions of the book, however, and the last section pp. 442—485, seem to be of more various, and on the whole very inferior merit.

In problems of purely mathematical interest, the value and importance of the results may be but little affected by a certain arbitrariness in the assumption of values for the constants introduced, or in the introduction or disregard of limiting conditions. Where, however, the mathematical problem is intended to represent a physical fact, and the actual circumstances are either too complicated or too little known to be susceptible of complete mathematical treatment, it becomes most important, not only to use the best attainable values of the constants, but to form a distinct idea of the limits within which these values are to be relied on, and to subject each step of the process, and each successive result, to independent criticism, in order to make sure that no essential consideration has been omitted in the transformation of the problem found in nature into one susceptible of being attacked by mathematical methods.

Prof. Haughton seems at times as if he had no idea of this—sometimes he lets himself be carried away by what a moment's thought must have shewn him to be only a plausible analogy[1]. At other

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[1] A curious instance of this is to be found in p. 4. After objecting, reasonably enough, to the use of the terms voluntary and involuntary, as corresponding to striped and unstriped muscular fibre, he makes the following astounding remarks: "Judging from the analogy of cleavage I have come to

times he forms a theory of the way in which an action takes place—takes the best value of the constants involved which he can get from materials ready to hand—performs his calculations and gives the result as certain, without stopping to enquire how far his theory is complete, or what will be the effect of an error in the assumed values of the quantities involved. A good instance of this on a small scale is found in the curious dissertation on the art of hanging, pp. 8—13.

He says, I believe quite truly, that sudden and painless death can be and ought to be produced in hanging by shock of the medulla oblongata caused by fracture of the vertebral column. He then goes on to say that he has "proved" — apparently by a single observation, pp. 11, 12—that 2240 ft. lbs. of work are just sufficient to accomplish this. He therefore goes on to calculate a formula giving the necessary drop in terms of the weight of the victim, and a similar one applicable to the American method of hanging. It never seems to occur to him that the force necessary to fracture the articulating surfaces of the axis, or to displace the odontoid process is likely to vary as much with differences of sex, build, &c., as the weight of the body itself—and that the force which would be insufficient to break the neck of a brawny ruffian of sixteen stone might pull off the head of a woman of half the weight. In the case quoted, in which the shock was exactly what was necessary, the man's height was increased an inch and a half by the process.

Another instance may be taken from § 5, on the absolute force of muscles, pp. 53—74. Prof. Haughton measured the cross sections of the flexors of the arm and leg of a selected subject, a blacksmith who had died of cholera. He measured the distances between the joints and the insertions of the muscles on another subject, a

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the conclusion that the striped structure in muscles, or tendency to cleave into discs, is due to their repeated contraction between two fixed or nearly fixed points of origin and insertion." And, after speaking of the observations of Sorby and Tyndall on cleavage produced by pressure, "Whenever, therefore, we find in muscular fibres a distinct origin and insertion, then contraction between these points will produce the pressure necessary for the development of cleavage at right angles to the length of the fibres." It is hardly necessary to remark (1) That the contraction of a muscular fibre between nearly fixed points produces tension and not pressure. (2) That if muscular contraction is produced, as some have supposed, by the mutual attraction of portions of the fibre and consequent compression of the intervening portions, this presupposes the longitudinal differentiation of the fibres which Prof. Haughton wishes to make it produce. (3) That there is no real resemblance between the structure of striped muscular fibre and true cleavage. (4) That the striped structure is perfectly developed in fœtal muscles before they have contracted at all. Indeed I supposed at first that the passage was not intended to be taken seriously—but it is solemnly referred to in the index as "striping of muscle, mechanical cause of," and I suppose must be deliberately put forward as an explanation. That such an idea should flash through the brain of an ingenious man is conceivable enough, but that it should be deliberately written down, sent to press, corrected in proof, and published in a book is a phænomenon of which I can find no plausible explanation. It is, however, hardly more than an exaggerated instance of the way in which the author seems to put down any idea which strikes him without the least attempt at self-criticism.

Frenchman of the same height and length of bones as himself, and finally determined by experiments on himself and a friend the force that could be exerted by these muscles. It is not quite clear whether the results given are the mean of those found by himself and his friend, or whether, as I rather infer, the experiments were made on his own arm and his friend's leg. From these he deduces the contractile force of muscle per square inch of cross section, and, as he finds the results from arm and leg come within about 15 per cent. of each other, he assumes the mean (taken with unnecessary if not misleading accuracy to two places of decimals) as the coefficient of muscular force applicable to all muscles of all animals, and even to the unstriped fibres of the uterus. In fact he assumes that all muscles are capable of contracting with a force of 102·55 lbs. per square inch of cross section, whereas what he has proved is that if the cross sections of his muscles and of his friend's are the same as those of the blacksmith, and the insertions the same as those of the Frenchman, the muscles of his arm contract with a force of 94·7 lbs. and those of his friend's leg with a force of 110·4 lbs. per square inch. He gives results of other authors differing by 50 per cent. or more, but always makes use of the value he has himself obtained. There seems no reason to believe that every cubic millimetre of muscle striped or unstriped throughout the animal kingdom is intrinsically equally powerful—and even if we confine our attention to the same muscles of individuals of the same species it is difficult to believe that there is no difference, except in cross section, between the muscles of a trained athlete and those of a sedentary valetudinarian.

Before going on to more complicated questions, I may give two more instances of the uncritical way in which the Professor too often argues. In pp. 2, 3, he argues, somewhat rashly I think, that the muscles which have the smallest fibres must be best provided with blood, and therefore best able to endure fatigue. He says accordingly that the muscles of women are capable of longer continued work than those of men. This is interesting if true—but it is certainly not proved by the fact referred to in a note that a mother or nurse can carry a child for a time which would be very fatiguing to the unaccustomed muscles of the father. Of course this is merely a matter of training. In many parts of the Alps men and women are trained indiscriminately to carry burdens. I have never heard that the women shew more endurance than the men, though I fancy that there is not much difference between them. It would be interesting to know whether the difference in the diameter of the muscular fibres in the two sexes is as great among these people as it is among the more sedentary races.

Again, on pp. 484, 485, after pointing out the extremely large "Coefficient of Refreshment" of the heart, he goes on "This interesting result is quite in accordance with the views of those anatomists who believe that the heart receives double the supply of arterial blood that any other muscle receives, in consequence of the semilunar valve, during life, not closing the openings of the coronary arteries during systole." On which it may be remarked (1) That the supply of blood to any muscle depends upon the number, dimensions and disposition of the arteries supplying it, and of the capillaries in connection with them. (2) That no one has yet explained how blood can flow into the coronary arteries while the heart is violently contracting, whether the orifices are closed or not. The effect of systole can hardly fail to be the expulsion of much of the blood from the substance of the heart, as well as from its cavities, leaving it in the most favourable condition for being refilled with fresh arterial blood during diastole.

The short articles on the muscular susurrus, and on the work done by the heart are interesting, but do not seem to contain anything very novel, except the very interesting observations on the great diminution of the frequency of the vibrations which give rise to the susurrus, in cases of paralysis agitans. In the latter far too great weight is given to the essentially unsatisfactory method of inferring the pressure in the heart from the distance to which blood is spirted from a cut artery.

The section (pp. 154—164) on the muscular forces employed in parturition is also interesting, though several objections may fairly be made to the arguments by which the somewhat surprising result is obtained that the expulsive force of the voluntary abdominal muscles is almost exactly ten times that of the uterus. Indeed, when our author comes to discuss more fully the action of the abdominal muscles (pp. 209—232), he gets results which he has some difficulty in reconciling with those he had previously obtained. This latter section however is not a favourable example of his method of treating the geometrical and mechanical problems of muscular action. He applies freely to the abdominal muscles Lagrange's theorem, and the equivalent results which he himself establishes, which have reference to the relation between the hydrostatic pressure within a closed vessel and the tension of the containing envelope supposed to be homogeneous, and either elastic or inextensible, forgetting, it would seem, the essential difference between such an envelope and a muscular one in which the tensions depend upon the direction of the muscular fibres, instead of being the same in every direction, or dependent only on the curvature, as assumed in the investigations. If we admit his calculations of the longitudinal and transverse strains produced at the navel by the abdominal muscles, the hydrostatic pressure which they can produce when acting together, will be the sum of that which they can produce separately, and Prof. Haughton would get the mean of the two values he obtains on p. 228, each of which is about half his former result. He goes on to seek for an escape from this difficulty by shewing that the pressure producible by the tension immediately above the pubes would be greater, forgetting, it would seem, that the pressure produced in a closed cavity by the contraction of part of its walls must be that due to the muscular forces where these are weakest. After this pressure has been reached, the contraction of the more powerful muscles would only alter the form of the cavity and forcibly extend the weaker muscles without increasing the pressure.

The "actual experiment" described on p. 163 does not seem to prove much. He there determines the greatest weight which could be raised by the action of the abdominal muscles, when it was put upon a disc placed over the navel of a man lying on his back. If the surface of the abdomen in the neighbourhood of the disc was flat the experiment can tell us nothing of the pressure produced by the tensions at the navel under normal circumstances. If, as is probable, the weighted disc caused a considerable depression, the direct action of the muscles would tend to raise it with a force which would be added to that exercised by the pressure of the contents of the contracting abdomen and comparable with it in magnitude.

The substance of a long section (pp. 74—136) on the comparative anatomy of the tendons of the Hand and Foot, and their mechanical uses, was laid before the Royal Society (*Proc. Roy. Soc.* XVIII. p. 359), and gave rise to some controversy at the time between Prof. Haughton and Prof. Humphry of Cambridge (see *British Medical Journal*, 1872, Vol. II. pp. 87, 228, 254, 341). Prof. Haughton finds in most animals, and notably in the *carnivora*, that the sum of the cross sections of the flexor tendons of the digits of the hind-limb is considerably larger when the tendons are measured in the toes, than when they are measured above their point of division, while in the fore-limb he finds an opposite result.

He attributes this to economy of material rendered possible by the existence of an enormous friction amounting sometimes to something like forty per cent. of the whole force applied to the tendon. He believes the action of a hand and foot to be essentially different, and that while in a hand the flexor muscles are employed in actually flexing the joints, in the foot they are habitually employed in resisting forcible extension during the actions of walking, scratching, &c.

No doubt there are actions in which the muscles of the hind-limb are employed in this way, though it seems very questionable whether this is their habitual or most important action—but the question is one which could hardly be settled without a very careful observation and analysis of the gait and action of different animals, something like what the Webers did for man in their "Gehwerkzeuge." It does not, however, seem necessary to answer this question in order to attack Prof. Haughton's theory. It is difficult to conceive how any one who has seen and handled a tendon and its sheath can believe that there is any considerable friction between them unless he is driven to it by the positive evidence of direct experiment. But of this there is no trace in the book, and there does not seem to be any sufficient reason in the observations quoted for making such a supposition even provisionally. Even if we assume, with Prof. Haughton, that all tendons contract and lose weight equally in drying, so that the weight of a length of "dried" tendon is an accurate measure of the cross section of the living one, it does not follow that the strength of tendons is exactly proportional to their cross section. It may well be, for instance, that the exigences of nutrition (always a difficulty in tendons) require a somewhat looser texture in the case of large than of small tendons, and it is quite conceivable that the sum of the breaking strengths of the tendons of the fingers may be no less than that of the breaking strengths of the tendons of the muscles which are connected with them, although the sum of their cross sections may be decidedly smaller.

With regard to the extra strength of the tendons distributed to the digits of the hind feet there is no difficulty. In many actions, and particularly in the tearing and scratching actions of the hind-limbs of the carnivora, the resistance to be overcome is by no means regularly distributed over the digits—and a tiger which was liable to break its tendon every time it applied the full force of its flexors to tear open its prey, while only one or two claws had good hold, would be soon worsted in the struggle for existence.

Much might be said, if time and the limits of an article permitted, on the interesting and suggestive, though not altogether satisfactory sections on the work done by muscles, and on general laws of muscular action—pp. 24—62, and 442—485. Till we know a good deal more of the mode of action of a contracting muscle than we do at present, it is probably scarcely possible to discuss satisfactorily what Prof. Haughton calls the "statical work done by muscles in continued contraction," i. e. the causes of the fatigue experienced when the muscle resists a pressure without doing external work at all. It does not appear that much is gained by Prof. Haughton's method of expressing it as the product of the moment, taken about the joint of the forces resisting the muscle multiplied by an "angular velocity," the physical significance of which it is difficult to see, particularly as the hypothesis that the extended arm begins to fall and is raised again at intervals corresponding to the period of the muscular susurrus is discussed and rejected.

The book concludes with a section on certain "General laws of muscular action." The author says:

"I have been led to the establishment of the three following laws, the proofs of which I shall give in detail :—

Law I. *In comparing together different muscles, the work done in contracting is proportional to the weight of each.*

Law II. *In comparing the same muscle (or group of muscles) with itself, when contracting under different external conditions, the work done is always constant in a single contraction.*

Law III. *When the same muscle (or group of muscles) is kept in constant action until fatigue sets in, the total work done, multiplied by the rate of work, is constant.*

For Law I. we are referred to Borelli, who enunciates what is equivalent to it, *provided the muscles are taken from the same animal.* This important proviso is tacitly ignored in Prof. Haughton's statement. How far the law, even with the proviso, may be treated as an accurate numerical statement seems somewhat doubtful, and no evidence on the subject is given.

The "proof" of Law II. consists of a discussion of some experiments of Prof. Stanley Jevons, in which it is shewn that, due allowance being made for the work done in setting the arm in motion, the work done in throwing weights to the greatest possible distance is nearly constant for different weights.

It is not obvious, nor I think probable, that the law would hold good if the time occupied by a contraction varied considerably in the different cases.

The third law is deduced from three kinds of experiments. (1) Raising a weight by a pulley. (2) Holding the arm extended with weights in the hand. (3) Raising weights by holding them in the hand and raising the arm from a vertical to a horizontal position, the weights raised and the time of raising them being varied in different ways. Assuming that "work" is done by resisting pressure which may be measured by the moment of the forces resisted, multiplied by a constant (the "angular velocity" of an earlier section), and that the work done in experiments of the class (3) may be measured by adding the "work" estimated in this way to the actual dynamical work performed, the results agree very fairly with curves drawn on the supposition of the correctness of the law. Considering, however, that the portions of the curves under observation do not differ materially in shape from those which would result from a different law, and that the results in the cases of the slower movements can hardly fail to be complicated by the process of refreshment which goes on simultaneously with that of fatigue, it seems very questionable whether much weight can be given to a law, of the rationale of which no explanation is offered.

I have endeavoured in the preceding paper to shew that a satisfactory treatise on animal mechanics cannot be written without an amount of cautious and patient criticism, and verification of hypotheses and arguments, which I have failed to find in Prof. Haughton's book; and I have thus been led to dwell almost exclusively upon those portions of it which seem to me imperfect or erroneous. I cannot close, however, without recommending the book strongly to the attention of all who are interested in the subject. It contains a great deal that is both interesting and important on the subject of muscular action, particularly in the sections on the Classification of Muscles, and on the hip and shoulder-joints to which attention has been called above, and the reader will not fail to find much that is both ingenious and suggestive even in those parts of the book from which he may be compelled to dissent.

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Outlines of Physiological Chemistry.—By CHARLES HENRY RALFE, M.A., M.B. *Cantab.* London, H. K. Lewis.

DURING the last few years physiological science in England has been advancing with remarkable strides. Physiological laboratories are now no longer adjuncts to a few of the large metropolitan medical schools, but have been already established in several provincial schools of natural science. This is all very gratifying; but we cannot close our eyes to the fact that the chemical side of physiology has been, and is, grievously neglected. The old proverb, "what is everybody's business is nobody's business," seems to apply with painful force to physiological chemistry. The science is claimed by two different classes of scientific men, chemists and physiologists, each having by their education a different method of regarding phenomena brought under their notice. The result is easily predicted, and only too apparent in the curriculum of our lecturers and the various examination papers which are so constantly being set. The fact that animal chemistry is in the hands of persons who regard it from two different points of view ought to be its great safeguard; and when chemists and physiologists come to work more together let us hope that the amount of work done may equal that produced by workers in the other branches of physiology. The little book before us professes to have been compiled "in the hope that it may furnish students and practitioners of medicine with a concise and trustworthy laboratory guide to the qualitative and quantitative analysis of the tissues, fluids and excretory products of the human body." The want of such a work in the English language as that described above was doubtless very great; but we rather hesitate to say that the author has fulfilled the task he has imposed upon himself with entire success. On our first cursory glance over the book we were inclined to imagine from the condensation of the matter and the profusion with which formulæ are scattered over its pages, that it was a production called forth for the purposes of "cramming," rendered necessary by the unfortunate examination systems of this country. On more careful examination, however, it appeared to be evidently a much more conscientious work, intended to give beginners an introduction to the subject, and as such all honour is due to the author. We think, however, it would have been better if he had confined his attention more to making the book a laboratory guide, and had sacrificed some of its completeness in the matter of formulæ and some other respects, at the same time giving fuller directions as to the practical working of the experiments described. To take an example, the directions given for establishing a pancreatic fistula are as follows: "The pancreatic fluid may be obtained for examination by opening the abdomen of a dog, and drawing down the duodenum, and separating the lower and larger pancreatic duct and passing a canula into it; the duodenum is then returned and the wound closed by a ligature, the canula left hanging out." This is so terse that we venture to predict that an operation conducted on these directions would be nearly certain to fail; no hint is given as to the position, size, or direction of the incision; in what part of the abdomen the pancreatic duct is to be sought for; the canula apparently is not to be tied in; and no precautions against accidents of bleeding, &c., which are so liable to embarrass the student during an operation, are given. The isolation of pancreatin is thus described: "Pancreatin is obtained by rubbing down the pancreas of a freshly-killed animal, in full digestion, with pounded glass, from which an aqueous solution is made and from which the pancreatin may be precipitated by alcohol." We do not know who was Mr Ralfe's authority for the above statement, nor can we say whether he had tried the experiment and was satisfied with the result, but the product of his operation would certainly be rather more than pancreatin. Indeed the purpose of the operations above described is not quite obvious, and would seem to do nothing but precipitate the soluble proteids resulting from the mashing up of the gland. The very interesting action of the pancreatic juice when continued for some time is thus dismissed: "According to Dr Kühne the prolonged action of pancreatic juice on newly formed peptones leads to the formation of leucin and tyrosin." This is not the statement one would expect in a "laboratory guide."

An appendix of fifteen pages is added to the book, containing a description of the appliances and methods of quantitative analysis; but this again is eminently impractical, and if used in the laboratory would lead to unreliable results. One method for the estimation of nitrogen is given, but no account whatever of the ultimate analysis of organic compounds is to be found. On the whole, we think that the little book is best suited for examination work, and unless the author modifies it very greatly it will not take up a position as an instructor to earnest practical students in the difficulties of animal chemistry.

Descriptive Catalogue of the Teratological Series in the Museum of the Royal College of Surgeons of England. By B. THOMPSON LOWNE, M.R.C.S. London, 1872.

IT is unfortunate that we do not possess in English any systematic treatise on Teratology. We have indeed many excellent essays on certain departments of the subject, such as the article "Hermaphroditism" by the late Sir J. Y. Simpson, originally published in *Todd's Cyclopædia*, and since reprinted in Simpson's collected memoirs, and Allen Thomson's well-known essay on Double Monsters, which appeared in the *London and Edinburgh Monthly Journal*, 1844. Vrolik also furnished a short article to the 4th vol. of the *Cyclopædia of Anatomy*. But there is no treatise in our language to be put on a par with Geoffrey Saint Hilaire's *Histoire générale et particulière des anomalies de l'organisation chez l'homme et les animaux*, or with Förster's *Die Missbildungen des Menschen*, or with Vrolik's *Vrucht van den Mensch en van de Zoogdieren.*

Mr Lowne's book to some extent supplies the omission to which we have referred; for it is not merely, as its title would lead us to infer, a descriptive Catalogue of teratological specimens in a particular museum, but many important general principles are expounded. The author prefaces his Catalogue with a concise general introduction to the subject. He arranges the specimens under the heads of Variation, Duplicity, Excess of Growth, Arrest of Growth, Arrest of Development, Disease, and then discusses briefly yet clearly the character and extent of each of these classes. In the body of the Catalogue also many general observations may be found which will interest those engaged in the study of Malformations.

The Causation of Sleep. A Physiological Essay. By JAMES CAPPIE, M.D. Edinburgh, 1872.

IN this essay the author keeps before him the following questions:—In what respect do the condition and action of the brain, or its relations, during the continuance of sleep, differ from those which are present during wakefulness? what is the physiological sequence of change from the one state to the other, and on what special change do the more characteristic phenomena of sleep depend? He argues that in the causation of sleep there is a combination or succession of conditions. The first is a modified nutrition in the nervous texture: the last is pressure on the surface of the brain, by an increase in the proportion of blood there, due to engorgement of the veins of the pia-mater. The connecting link between the two is a weakened capillary circulation through the brain itself, owing to diminished activity of brain tissue, and a less energetic evolution of nerve force.

Lessons in Elementary Anatomy. By ST GEORGE MIVART, F.R.S. London, 1873.

MR MIVART has prepared, in the hope that it may serve as a handbook of Human Morphology, this volume as one of the series of school class-books now in course of publication by Macmillan. He devotes upwards of one-half the book to the skeleton, and leaves only the smaller proportion for the consideration of the other organic systems. His acquaintance with facts and his descriptive style are such as we might naturally expect from so skilful a comparative anatomist and so practised a writer as Mr Mivart. We have some doubts however how far the book is well adapted to be introduced as a lesson-book in schools, unless the teachers are themselves accomplished anatomists, and the schools are provided with a well-selected museum of osteological and other specimens. Object teaching is the very essence of a biological training, and without it instruction in natural science partakes too much of the nature of "cram."

We can recommend this book however to the notice of those teachers of anatomy in our schools of medicine, whose instructions are imparted solely from the stand-point of human anatomy. In it they will be enabled to recognise that the human body consists not only of parts on which the surgeon may be required to operate, or the diseases of which the physician may have to diagnose, but that the study of its mode of construction teaches important lessons on those great principles of organisation which it shares in common with other vertebrata.

The Comparative Anatomy of the Domesticated Animals. By A. Chaveau, Professor at the Lyons Veterinary School. Second edition, revised and enlarged with the co-operation of S. Arloing, late Principal of Anatomy at the Lyons Veterinary School, Professor at the Toulouse Veterinary School. Translated and edited by George Fleming, F.R.G.S., M.A.I., Veterinary Surgeon, Royal Engineers.

We welcome the appearance of this book in English as likely to raise the standard of veterinary science in this country. The work of M. Chaveau is not merely an excellent descriptive treatise on Anatomy, but, as stated in the preface, it aims at a philosophical character. As an enthusiastic admirer of Cuvier and Geoffrey St Hilaire, the author glories in belonging to their school, and observes that the prevailing idea in the work has been inspired by their labours. Accordingly, the object of the book being the study of veterinary anatomy, the Horse is usually taken as the type and all the organs of an apparatus are studied in the Horse; afterwards the same organs in the other species are studied in the same order, and, finally, they are compared with the corresponding parts in man. The descriptions are good and clear. A microscopical account of the several tissues and organs is added. The translation is well done; and it forms a very valuable addition to the library of the veterinary student. It is copiously and well illustrated, many of the illustrations are original; and we regret to be obliged to express the wish that the sources had been indicated from which those that are not so have been taken.

Handbook for the Physiological Laboratory. By E. Klein, M.D.; J. Burdon-Sanderson, M.D., F.R.S; Michael Foster, M.A., M.D., F.R.S.; and T. Lauder-Brunton, M.D., D. Sc.; edited by J. Burdon-Sanderson. London, J. and A. Churchill, 1873. 2 Vols. 1 Vol. Text, 1 Vol. Plates.

This work is one of the most important contributions to scientific literature which has appeared during the present year. It is a book which will be much appreciated by all investigators in the field of physiology, because it contains a description of the methods of research which have contributed so much to the advancement of physiological science in recent times. The authors are well known as physiologists who have devoted special attention to the subjects they profess to teach, and they were therefore eminently qualified for the task they have on the whole successfully accomplished. Physiology has now taken possession of such a wide area in the field of science, and includes a knowledge of so many correlated subjects, such as physics and chemistry, as to render it almost impossible for one man in a short lifetime to attain to the position of an authority or expositor in all departments. One man devotes himself to histology, another to experimental physiology, while a third is known chiefly as a physiological chemist. We therefore think the editor acted wisely in calling to his aid men having special knowledge, and in our opinion he could not have made a better selection than in the present instance. On the whole, Dr Sanderson has succeeded in producing a work which is a credit to physiology, and which has no counterpart in any other language.

Having made these preliminary statements, we shall now notice more particularly the different sections of the work. We consider it unfortunate that the plates were separated from the text, because it is always more convenient in reading to be able to refer easily to any illustration. The responsibility of this, however, the editor throws upon the publishers. It is evident sufficient care has not been taken in the text as to references to the plates, and in the same plate various figures are mixed up so as to be at the least confusing, more especially to a tyro in physiology. These, however, are minor defects, which do not seriously detract from the value of the work.

The section upon histology is by Dr Klein, now Assistant Professor in the Pathological Laboratory of the Brown Institution, and formerly Privat Docent in Histology in the University of Vienna. Histology, during the last ten years, has made great advances, not so much in the way of generalizations of wide scope like that of the cell-theory of Schleiden and Schwann, but more in the applications of better methods of observation. Attempts have been made successfully to examine tissues in two ways: first, under conditions similar to those in which they exist during life; and secondly, after the action of re-agents which have the property of "fixing" delicate tissues or organs in their normal shape and position, or of staining them in such a way as to render minute structure apparent. Full details are given by Dr Klein respecting each of these modes of investigation. It appears to us that this section is more suitable for the advanced student in histology than for the ordinary medical student of our universities and colleges. It would be of almost no use to the latter; he has not sufficient preliminary knowledge, and when he commences histology he scarcely knows one end of a microscope from the other. For him therefore words or phrases such as "objective," "eye-piece," "Hartnack's No. 10 immersion," &c., are unintelligible. He has no ideas of the optical principles or mechanical construction of the microscope. Dr Klein would undoubtedly have added much to the utility of this portion of the Handbook by giving a short description of the microscope as an instrument of research, and by defining the terms he employed. On the whole, however, Dr Klein has given us an admirable compendium of the methods of histological investigation, which will be of great service to those who have not had opportunities of becoming acquainted with what has recently been done in this direction. This part will often be referred to by advanced students, and will be a valuable guide to them.

The sections on blood, circulation, respiration, and animal heat are by the editor, Dr Burdon-Sanderson. Under the first head, "the Blood," we have admirable expositions of the chemical and physical properties of that fluid. We have also a minute description of the methods of obtaining and analysing the gases of the blood, a matter of much importance. These methods cannot be practised by the ordinary student of medicine, but for the student of physiology a knowledge of them is invaluable. The chapter on the circulation is subdivided into two parts, first, the arteries, and, second, the heart. There is also a supplement relating to the absorption by the veins and lymphatics. The method of the author with reference to the first part is, first, to measure arterial pressure or tension; secondly, to record the variations of arterial tension during each cardiac period in two ways: (*a*) by means of the spring kymograph of Fick, and (*b*) by the sphygmograph of Marey; thirdly, to watch the circulation in transparent tissues such as the fish-tail, and the mesentery, web, and tongue of the frog, or in the mesentery of warm-blooded animals; and, fourthly, to study the influence which the vaso-motor nerves have on the blood-vessels. As the blood-vessels during life are not passive elastic tubes conveying fluid, but also tubes constantly undergoing changes in calibre from the influence of the nerve centres through the nerves distributed to them, Dr Sanderson's method is truly philosophical, and is the only one by which the physiology of the circulation can be correctly apprehended. With regard to the heart, Dr Sanderson describes how the movements of the heart, the cardiac impulses and the action of the valves may be studied. Here, again, he had to deal with a living contractile organ under the control of various stimuli, and accordingly he describes the experiments necessary for demonstrating the influence of the intrinsic ganglia, and of the sympathetic and pneumogastric nerves. We doubt much if all the experiments described could be shown to a class of Practical Physiology, but the details given will be useful to the investigator who wishes to corroborate previous experiments, or to pursue original research. The chapters on respiration and animal heat abound in useful practical details. This part of the Handbook justifies the high estimation in which Dr Sanderson is held as a practical physiologist, and will prove a great assistance to all advanced students.

The functions of muscle and nerve are dealt with by Dr Michael Foster in a very lucid manner. All the experiments detailed in this section require, to ensure success, attention to minute arrangements, which are here given with great precision. Many cannot often be demonstrated to a class of students on the first trial because the conditions are complex, but any one carefully following the directions given by Dr Foster will no doubt obtain all the results. As an illustration take the case of the law of contraction of Pflüger which is confessedly one of the most difficult points to demonstrate in a course of practical physiology. Even eminent authorities who have published on the subject, differ as to the results they have obtained, no doubt while alone and without the distractions of a class. A teacher cannot expect to be able to demonstrate these facts off-hand to a class. Many of them can only be performed by personal devotion of quiet hours of work, and cannot successfully be done for or by medical students who have many other classes to attend to and little time. But any one who professes to study physiology as such, with the view of becoming a teacher or investigator, ought to study carefully this section of the work and train himself by performing all the experiments detailed so succinctly by Dr Foster. We miss, however, any reference to apparatus for measuring the rapidity of nerve current, such as the myographion of Helmholtz and Du-Bois Reymond.

The last section of the work is on the physiology of digestion and secretion, by Dr Brunton. Of this part we can only write in terms of unqualified praise. Dr Brunton evidently understands the difficulties of practical teaching, and he has accordingly specially indicated those experiments which can be readily done in the presence of a class of students, and which are specially adapted for teaching purposes. In an appendix we have many useful practical notes on manipulation.

In conclusion we have to state our opinion that this Handbook, on the whole, is worthy of the reputation of the authors. It has defects, but these are not of much importance. There is a want of balance between the different parts which was, of course, to be expected in a work written by different men. We are surprised at the entire omission of the experimental physiology of vision, hearing and voice. These subjects are of great importance and can be readily illustrated by experiment. They are carefully taught in courses of physiology in French and German universities, and it is to be much regretted that in this work, which we regard as an expression of the state of physiological knowledge in Great Britain, no reference is made to them. This ought to be remedied in the next edition.

This Handbook will now find a place in every laboratory. It is not suitable as a text-book for the ordinary student of medicine, but a judicious teacher will find in it numerous illustrative experiments and procedures to which he can direct the student's special attention. It is a handbook for advanced students, for teachers and experimentalists. Its publication is a stimulus to physiology, and we shall soon expect to see fruits in the shape of substantial work done by many of our younger physiologists.

REPORT ON THE PROGRESS OF ANATOMY.

By PROFESSOR TURNER[1].

OSSEOUS SYSTEM.—Joseph Hyrtl describes and figures (*Denk. der Math. Naturwiss. der Akad. Vienna*, 1871) specimens of human crania which possessed DUPLICITY OF THE CURVED LINE ON THE PARIETAL BONE. He also figures three fœtal crania in each of which a suture, beginning at the side of the coronal, traversed the parietal bone in the antero-posterior direction, so as in one case almost, and in two cases entirely, to subdivide it into an upper and a lower segment.——Wenzel Gruber records another case of SUPERNUMERARY CARPAL BONE (*Bull. de l'Acad. Imp. de St Pétersb.* VIII. 705), from subdivision of the scaphoid into two secondary bones: and in *Virchow's Archiv*, LXV. 425, he describes an ELEVATION on the POSTERO-SUPERIOR ANGLE of the left SCAPULA, in relation to the insertion of the serratus magnus, and possessing in connection with it a synovial bursa.——H. Wolfermann communicates (*Reichert u. Du Bois Reymond's Archiv*, 1872, 312) the results of a comparative enquiry into the ARCHITECTURE OF THE BONES.—John Struthers gives an account (*Lancet*, Feb. 15, 1873), of the occurrence of the PROCESSUS SUPRACONDYLOIDEUS HUMERI in the father of a family and in four out of seven of his children. The father and three children had it in the left arm, the fourth child in both arms.——Ludwig Stieda publishes a separate memoir, Leipzig, 1872, ON THE FORMATION OF BONE. In the first part of this essay he describes the observations which he has specially made into its development, and in the second part he gives a historico-critical review of the researches of previous observers. He first investigates the bones which form in fibrous membranes, as the lower jaw, and concludes that the bony tissue arises out of an osteogenetic substance (osteoplasts), which proceeds from indifferent embryonic connective tissue. He then examines into the formation of the "cartilage bones," and his conclusion is that the cartilage only possesses a provisional import, that the cartilage tissue atrophies and disappears, and that in its place appears the new formed osseous tissue, which stands in no genetic relation with the cartilage, but which arises as in the "membrane bones" out of the osteoplastic cells. Further he maintains that the marrow cells (osteoplasts) do not arise from the cartilage cells, but that the medullary tissue is a direct prolongation of the osteo-genetic tissue found lying beneath the periosteum. He regards true bone as a tissue *sui generis*, which belongs to the category of the connective substances. Bones grow by the apposition of new bony substance to the old: in the long bones the increase in length is by apposition at the confines of the cartilage, and in thickness by apposition of new material directly beneath

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[1] To assist in making this Report more complete Professor Turner will be glad to receive separate copies of original memoirs and other contributions to Anatomy.

the periosteum; whilst the cranial bones grow on their surfaces, from the periosteum, and at their margins from the intermediate connective tissue.——A translation of C. Heitzmann's researches on BONE AND CARTILAGE appears in *Quart. Journ. Mic. Sc.*, April, 1873.

FIBRO-CARTILAGE.—Oscar Hertwig describes (*Schultze's Archiv*, IX. 80) the *structure and development of elastic tissue in the Yellow Cartilages.* He examines the cartilage of the human ear and of various mammals. The elastic fibres arise immediately after the first appearance, of an inter-cellular substance, or simultaneously on the surface of the protoplasm. The cells which form the earliest elastic fibres lie in rows perpendicular to the surface of the cartilage. From the commencement the fibres are insoluble in potash-ley. They are not derived from a conversion of a homogeneous cartilaginous basis substance, which is first formed, but directly from the protoplasm of the cells. Subsequent development of the fibres is due to intus-susception in the extra-protoplasmatic substance, so that new fibres either enclose the old or grow out of them; or in the immediate vicinity of the persisting cells, which continue to exhibit their formative activity in various ways.

MUSCULAR SYSTEM.—J. Beswick Perrin records (*Med. Times and Gaz.*, Dec. 7, 1872, and Jan. 11, 1873) variations in muscular arrangements which he has met with in the Dissecting Rooms of King's College, London, during the sessions 1868—69, 1869—70 and 1870—71. He classifies them into adventitious, which include muscles not common to man; hetero-morphous, where the human arrangement is departed from; absentaneous, where muscles, which, as a rule, are present, are occasionally aberrant. The most important varieties are additional fusiform muscles from the scapula to the levator anguli scapulæ: a *third head to the biceps brachii* from the capsular ligament of the shoulder; another from the humerus below the insertion tendon of the coraco-brachialis; a *levator claviculæ;* an *extensor medii digiti; a peroneus quartus;* and various modifications in the *extensor carpi radialis longior.*——Davies-Colley, F. Taylor and B. N. Dalton record variations in muscles observed in Guy's Hospital Dissecting Room from Oct., 1870 to June, 1872 (*Guy's Hosp. Rep.* 1873). The most important are: a *levator claviculae;* variation in the *rhomboidei and digastricus*: a second *rectus capitis posticus minor;* specimens of *rectus sternalis and supracostalis:* a *biceps brachii* with four heads: variation in external oblique: additional head to *adductor longus.*——John Tweedy relates (*Lancet*, March 29, 1873) a case of absence of the *thoracic portion of the pectoralis major* and the whole of the pectoralis minor: and at the meeting of the Clinical Society, Feb. 28, a case of absence of the left pectoralis major was reported by Burney Yeo.—W. Turner may refer here to a subject he dissected in 1865, in which on the right side a hiatus existed in the pectoralis major owing to the absence of any fibres of origin from the second costal cartilage of the corresponding part of the sternum.——Wenzel Gruber describes (*Bull. de l'Acad. Imp. de St Pétersb.* VIII.) a case of right *m. cleido-hyoideus* and left *m. supraclavicularis*; also a right *m. sterno-fascialis* which ended in the fascia of the neck in the *trigonum omo-hyoideum;* also a supernumerary *m. obliquus ext. abd.* from the eleventh right costal cartilage to end in the aponeurosis of the external oblique; also a *m. protractor arcus cruralis* from the horizontal ramus of pubis to the crural arch: also a *tensor* of the posterior layer of the sheath of the *rectus abdominis* arising from the tuberculum pubis; also a *tensor* not only of that sheath but of the fascia transversalis; also a *m. obliquus internus* the inguinal portion of which was absent; also, p. 736, a variety of the *m. tensor fasciæ suralis,* which arising from the semi-tendinosus passed down the back of the leg to end in the back of the tendo-Achillis. ——Bruhl has described (*Journ. de Zool.* 1873, 32) a case of a *supernumerary long extensor of the great toe* inserted partly into the tibial side of the base of the 1st phalanx partly along with the tendon of the short extensor. Jelenffy, of Pesth, discusses (*Pflüger's Archiv,* 1873, p. 85) the action of the MUSC. CRICO-THYROIDEUS: he agrees with the view that it is a tensor of the vocal cords, but considers that it acts in a threefold way; *a,* through bending over of the cricoid cartilage backwards; *b,* through reciprocal separation of the cricoid and thyroid cartilages from each other in the direct sagittal direction; *c.* through a forward movement of the angles of the thyroid cartilage.

Several memoirs on the STRUCTURE OF TRANSVERSELY STRIPED MUSCULAR FIBRE have recently appeared. T. W. Engelmann has two elaborate articles in *Pflüger's Archiv,* 1873, pp. 33, 155. He examines the structure of the fibre during rest, activity and rigidity. He recognises in a normal fibre at rest four different kinds of transverse stripes; I. a clear band, refracting the light very feebly, subdivided into halves by II. an opaque strongly refracting stripe: III. a moderately opaque, tolerably strongly refracting band, in the middle of which is IV. a clearer stripe refracting the light more feebly. In all fibres with very broad transverse striæ the opaque stripe II. may be subdivided into three transverse striæ, a middle more opaque and two lateral clearer, and he considers that in those fibres where this subdivision has not yet been recognised it must be held to exist. I. and II. together form the isotropic band. III. and IV. together the anisotropic band. In the stripe II. of the isotropic band, the middle more opaque portion he names intermediate disc (*zwischen scheibe*), the two lateral, secondary discs (*neben scheiben*), whilst he adopts Krause's term *Grund membran* for the three collectively. For IV. he adopts Hensen's term, middle disc (*mittelscheibe*), whilst to the parts of III., in the middle of which IV. is situated, he gives the name of cross discs (*Quer scheiben*). He then enters minutely into the characters of the individual discs. He holds that a fibre at rest is an aggregate of different kinds of discs which in the long axis of the fibre adhere so as to form prismatic fibrillæ, in the transverse direction adhere so as to form in general parallel discs. In the second article Engelmann describes the fibre in a state of activity, the alterations in form, volume, optical appearances and mechanical properties which take place during contraction, and he concludes with some remarks on the cause of contraction.——Fr. Merkel completes (*Schultze's Archiv*, IX. 293) his memoir on striped fibre by giving a chapter on the process of contraction as it appears with polarized light.——C. Sachs commences (*Reichert u. Du Bois Reymond's Archiv*, 1872, 607) a memoir on the structure of striped fibre, the consideration of which must stand over until it is completed and the plates are published.——E. A. Schäfer communicates (*Roy. Soc. London*, April 3, *Abstract in Nature*, April 24), an investigation on the structure of the muscles of the limbs of the water beetle. He considers that a muscular fibre consists of a homogeneous basis substance, apparently formed of alternate discs of a dim and a bright substance, in which are imbedded minute rod-like bodies having their axes coincident with that of the fibre itself. He calls these *muscle-rods*, and in the muscle at rest they are uniformly cylindrical, but when in action they terminate at each end in a knob so as to be dumb-bell shaped. These knobs give the appearance of the line of dots existing in the middle of each bright transverse band of the fibre (corresponding to stripe II. of Engelmann, Reporter); the dim disc again is that in which the shafts of the muscle-rods are imbedded. From several considerations it is argued that the bright transverse bands in muscle are produced by the juxtaposition of the rod heads. The author states that all the basis substance of a fibre is doubly refractive, the rods alone being singly refractive. He regards the basis substance as the true contractile part, the rods as elastic structures to restore the fibre to its original length.——P. Tergast communicates some observations on the *numerical relations* of the *nerve fibres* entering a muscle to the *muscular fibres* (*Schultze's Archiv*, IX. 36).

MOTION AND LOCOMOTION.—Marey contributes (*Robin's Journal*, Jan. 1873), a memoir on TERRESTRIAL LOCOMOTION both in bipeds and quadrupeds. By means of a specially constructed shoe he studies the human movements in walking, running, galloping and leaping. He also adapts a special apparatus to the feet of the horse, and studies by its aid the various paces of this animal. The memoir is illustrated by figures of the apparatus, and by diagrams and tracings of the oscillations which have occurred during the movements.——A. W. Volkmann examines (*Virchow's Archiv*, 1872, LVI. 467) into the conditions under which a man standing erect can, without altering the position of his feet, TURN HIS BODY, so that the face may look almost backward.

SYNOVIAL MEMBRANES.—Wenzel Gruber describes (*Virchow's Archiv*, LVI. 428) a series of cases of HERNIA-LIKE PROTRUSIONS of these membranes: in the scapulo-humeral joint, the radio-carpal, the carpal, and the carpo-metacarpal.

NERVOUS SYSTEM.—W. Betz details his experience (*Schultze's Archiv*, IX. 101) on the methods of examining the CENTRAL ORGANS OF THE NERVOUS SYSTEM in man.——Axel Key and G. Retzius have studied (*Nord. Med. Arkiv*, IV. and *Schultze's Archiv*, 1873, 308) the anatomy of the nervous system, more especially in connection with the arrangement of the INVESTING TISSUES and the SEROUS SPACES. The arachnoid membrane with its trabeculæ, the pia mater, the perineural and epineural investment of the cerebro-spinal nerves; the sub-arachnoid spaces in connection with the spinal cord, the roots of the nerves and the spinal ganglia; and the structure of the Pacinian corpuscles, are described and beautifully figured.——Anton Spedl makes (*Reichert u. Du Bois Reymond's Archiv*, 1872, 307) some observations on the PHRENIC NERVE.——Hagemann undertakes (*Reichert u. Du Bois Reymond's Archiv*, 1873, 429) a comparative anatomical investigation into the STRUCTURE OF THE PINEAL GLAND. He distinguishes in it a supporting framework formed of connective tissue and a parenchyma. The septa formed by the supporting framework in the substance of the gland enclose parenchymatous tissue so as to form "follicles." The parenchyma consists of two kinds of cells, roundish and spindle-formed. Nerve-fibres enter the gland anteriorly from the commissures of the peduncles; he thinks that they ramify between the follicles, and that the nerve ganglion cells which the pineal gland also possesses lie in the same localities.——C. Kupffer considers (*Schultze's Archiv*, 1873, 387) the RELATION OF THE NERVES OF GLANDS TO THE GLAND-CELLS. He investigates the salivary glands of insects and the larvæ of Muscidæ with the view of ascertaining if the nerves do, as Pflüger has maintained, come into direct relation with the secreting cells within the acini. His attention was first directed to the relations of the tracheæ to the gland, and he saw that not merely did they turn round the organ, but that a not inconsiderable number of fine twigs pierced the membrana propria. These twigs then ran between the large plate-like cells. From the sheath of these intra-cellular tracheæ fine, pale fibrillæ proceeded which entered the cells; these fibrillæ he considers to be nerves. He holds it to be completely established that tracheæ enter into the composition of the salivary cells of the larvæ of muscidæ. He then examined the salivary glands near the œsophagus of *Blatta orientalis*. These glands are provided with a very rich nervous apparatus, which derives its roots from the supra-œsophageal ganglion and the abdominal cord. In them the entrance of numerous nerves into lobules, the blending of the nerve sheath with the membrana propria, and the entrance of the nerve fibrillæ into the interior of the acini may easily be observed. At the first glance it seemed as if the whole *Fibrillenstrang* entered completely into the adjacent or the two adjacent cells immediately on entering the acinus, but closer observation showed him that the greater part of the fibrillæ passed further into the interior of the acinus. The fibrillæ did not blend with the substance of the cells where they came in contact with them, but passed far into their interior so as to be imbedded within the substance of the cells. He has not succeeded in tracing a direct connection between the fibrillæ and the nucleus. He describes also certain hollow pear-shaped capsules, in connection with the secreting cells of these glands.——J. Schöbl describes (*Schultze's Archiv*, 1873, 197) the mode of

TERMINATION of the NERVES IN THE TACTILE HAIRS of the mammalia. He recognises two kinds of tactile hairs, a small and a large, with intermediate transitional forms; the large possess well-developed cavernous bodies which lie between the outer and inner fibrous coats; the small have none. The nervous tactile apparatus consists in the tactile hairs of the bat's wing, of a nervous ring and a partial envelopment of the cellular body of the root with nerve fibres; in the tactile hairs in the mouse's ear of a nerve ring and glomerulus or coil; in others of a nerve ring with which the modified glassy membrane is in connection.——H. Hoyer gives (*Schu'tze's Archiv*, 1873, 220) a long communication on the NERVES OF THE CORNEA. He examines the arrangement in all the divisions of the vertebrata with chloride of gold after Cohnheim's method, and gives some beautiful figures of the extremely delicate nervous plexus found in this structure.——In an article entitled CYNO-PHRENOLOGY (*Boston Med. and Surg. Journal*, Jan. 23, 1873) B. G. Wilder reports on a collection of brains and embryos in the Museum of Comparative Zoology, Cambridge, U. S. He considers that real advances into the determination of the coexistence of certain mental characteristics with a given pattern of brain must be made on the brains of dogs rather than of men, as it is more practicable to obtain the brains and ascertain the mental characteristics of a number of dogs than of a number of men.

VASCULAR SYSTEM.—Variations in arteries have been described (*Guy's Hospital Reports*, 1873) by Davies-Colley, F. Taylor, and B. N. Dalton; the most important of which are: left carotid arising from innominate, ten cases of high division of the brachial, in one of which a *vas aberrans* arose from one of the arteries just above the elbow, and after a course of 2½ inches joined the ulnar: once the right kidney received an artery from the common iliac, once the external iliac divided into profunda and superficial femoral half an inch above Poupart's ligament.——M. Duret has described (*Archives de Physiologie*, 1873, 97) the ARTERIES OF THE MEDULLA OBLONGATA. He divides them into three sets, lateral to the roots of the nerves, median to the floor of the 4th ventricle, and arteries to the olivary bodies, pyramids, restiform bodies, &c.

KIDNEY.—W. Turner records here two cases of HORSE SHOE KIDNEY. One was found in a male subject in the dissecting room of the University of Edinburgh in November, 1872, the other was observed by J. Batty Tuke in the following month in the *post-mortem* examination of a patient who died in the Fife and Kinross Asylum. In both cases the isthmus connecting the right and left kidneys was situated below, and lay in front of the aorta and inferior cava close to the bifurcation. The concavity therefore of the horse shoe was directed upwards. The hilum was situated on the anterior surface of each lateral half, and in both specimens the ureter passed off from the lower end of the hilum on each side. In the Reporter's case a single renal artery supplied each half of the double organ, and a special branch entered the isthmus where it joined the left lateral half. In Dr Tuke's case each lateral half had two renal branches of the abdominal aorta, and a special branch from the right common iliac artery entered the isthmus where it joined the right lateral half of the kidney: the weight of this specimen was 20 oz.

MALFORMATIONS.—Three cases of malformation in the human fœtus are described by Dr Orth (*Virchow's Archiv*, LIV. 492). They belong to the class ACARDIACI, and two at least to the subdivision named by Förster AMORPHI.——M. Roth records (*Virchow's Archiv*, LVI. 197) several cases of formation of DIVERTICULA in connection with the duodenum; and on p. 271 N. Duhay describes a case of incarceration owing to ABNORMAL FORMATION OF THE MESENTERY. In the same vol. p. 268, Kuhnt relates a case of DUPLICITY IN BOTH HANDS AND FEET. In each foot not only were four toes situated on the outer side of the great toe, but on its inner side two well-shaped toes were placed. Each hand had 5 digits only, but these were one middle, two ring and two little fingers, the thumbs and indices being unrepresented. On p. 421, A. Ewald describes a case of CONGENITAL HYPERTROPHY OF THE LEFT HAND.——Jos. Leidy mentions (*Proc. Acad. Nat. Sci. Philadelphia*, May 9, 1871) that in the Museum of the University of Pennsylvania is a specimen showing POLYDACTYLISM IN THE HORSE, in which an abnormally developed metacarpal has a toe with two phalanges, one of which last is inclosed in an irregular hoof. He refers also to a case recorded by Mr Mason in the *Proc. Roy. Asiatic Soc.*, Bengal, where the usual "splint-like rudiments of the metacarpals of the 4th toe in the fore feet, had given rise to an additional toe provided with three phalanges, of which the last is incased in a hoof."——In an essay on HEREDITARY TRANSMISSION OF STRUCTURAL PECULIARITIES (*Brit. and For. Med.-Chi. Rev.* April, 1872), J. W. Ogle collects together a number of cases of defect or variation as to digits and other structural peculiarities.——H. Gripat gives an account (*Journal de Zoologie*, 1873, 4) of an ACEPHALOUS CALF.——P. D. Handyside in this *Journal*, Nov. 1872, communicates two cases of QUADRUPLE MAMMÆ IN MEN, and Max Bartels describes and figures (*Reichert u. Du Bois Reymond's Archiv*, Nov. 1872) another case.——In *Edin. Med. Journal*, Jan. and Feb. 1873, T. Graham and P. D. Handyside describe a case of HYPOSPADIA WITH CLEFT SCROTUM.——G. B. Ercolani gives a methodical description (*Mem. dell. Acad. di Bologna*, 1872) of cases of diverticula of the URINARY BLADDER, of double bladder and of dilation of the Urachus.

OVUM AND OVARY.—C. Weil (*Medic. Jahrb.* I. 1873 and *Medical Record*, Jan. 8, 1873) describes the FECUNDATION AND DEVELOPMENT OF THE OVUM OF THE RABBIT. He observed spermatozoa moving in a lively manner between the 17th and 46th hours after fecundation, within the zona pellucida and in the albuminous envelope. Four instances are given of unchanged spermatozoa having been seen within the substance of the germ itself, besides numbers between the germ and the zona pellucida. When the ovum had reached the uterus, no spermatozoa could be seen either within or without the germ. Weil concludes that the spermatozoa unite with the germ in an intimate way in order that the ovum may be fertilised. Weil's observations confirm those of Bischoff relative to the changes which take place in the ovum as it passes along the oviduct.——H. Kapff describes in *Reichert u. du Bois Reymond's Archiv*, 1872, 513, researches into the OVARY and its relations to the PERITONEUM. He agrees with Waldeyer that a positive difference in colour exists between the surface of the ovary and the adjacent part of the peritoneum. He does not however confirm the statement that a sharp line of demarcation exists between the epithelium investing the ovary and that covering the peritoneal membrane, his view being that a gradual transition from the smaller peritoneal to the larger ovarial epithelial cells takes place. Further, he does not hesitate to say that a sub-epithelial connective tissue exists under the epithelium both of the ovary and the adjacent part of the peritoneum, so that, contrary to some recent statements, he believes that the entire constituents of the peritoneum are prolonged over the ovary. He then proceeds to criticise Waldeyer's observations on the formation of the ovarian follicles and the ova from the ovarial epithelium, and his conclusion based on his own observations is quite opposed to Waldeyer, for he says that the surface of the ovary is in no way concerned in the formation of the follicles in its interior, therefore also not in the formation of the ova. Kapff then communicates some observations on the development of the genital gland.

PLACENTA.—Several contributions have recently been made to the *anatomy of the human placenta.* W. Turner in *Proc. Roy. Soc. Edinb.* May 20, 1872, and in this *Journal*, VII. 120, J. Matthews Duncan in *Ed. Med. Journal*, Jan. 1873, and F. N. Winkler in *Archiv für Gynækologie*, 1872, 238, bring forward various facts in support of the view that the placenta contains a cavernous sinus system, through which the maternal blood circulates. Braxton Hicks, again, in a memoir in *Trans. Obstet. Soc. London*, 1872, argues against such an intraplacental circulation of the maternal blood. He re-describes the specimens, which he regards as supporting his views, previously recorded by him in this *Journal*, VI. 405, and adduces a number of additional observations. J. B. Pettigrew also in *Edin. Med. Journal*, Nov. and Dec. 1872, publishes a lecture in which he speculates on the structure and function of the placenta. He conceives that in the human placenta, as in the diffused placenta of a mare or a cetacean, the villous surface of the chorion is applied to the mucous lining and capillary vessels of the uterus, that the former, in short, so far as relates to the fœtal and maternal vessels, does not differ from other mammals. Further, he believes that the utricular glands persist, and that their secretion not only assists in nourishing the fœtus, but acts as an osmotic medium for promoting the interchange between the blood in the capillaries of the fœtal villi and the capillaries in the uterine mucous membrane. Ingenious though this hypothesis undoubtedly is, yet the author does not support it by any detailed observations of his own of the presence of either utricular glands or maternal capillaries in a fully-formed human placenta. And though the structural conditions referred to are undoubtedly met with, as the Reporter has himself shown, in the diffused placenta of a cetacean, yet there is no evidence of their existence in the mature human placenta.

Morphology of the Limbs.—Several essays on this subject have recently appeared. Burt G. Wilder draws up a memoir (*Proc. Boston Soc. Nat. Hist.* XIV. 1871) on *Intermembral homologies,* which he intends as an index of what has been done and what remains to be done for the elucidation of this difficult department of morphology. In a paper by this author, noticed in our Report, II. 404, it was stated that in his opinion the thumb and little toe, minimus and great toe, radius and fibula, ulna and tibia are homologous parts. He believes, with Folz and Wyman, that the fore and hind limbs are antitropically or symmetrically related: but since the publication of his former papers he has been led to modify his previous views respecting the normal position of the limbs, and in so far he concedes a point to those who hold that the relation of the limbs is one of syntropy or parallelism. Wilder has collected together in a convenient form a large amount of information respecting the opinions and statements of the various anatomists who have written on this subject.——C. Martins, in an article in *Dict. Encyc. des Sc. Medic.* 1873, compares the *thoracic and pelvic extremities,* and repeats his well-known theory of their morphology based upon the twisting of about 180° which the humerus has undergone.——Alex. Rosenberg investigates the *development of the skeleton of the limbs* (*Siebold u. Kölliker's Zeit.* 1873, 116) in pigs, the *Elen,* sheep, horse and various birds. The investigation has been conducted with especial reference to the Darwinian theory of descent, and the facts which he describes are looked upon as of value according to their bearing either for or against this theory. The tarsal, carpal, metatarsal and metacarpal bones form more particularly the objects of investigation.——In G. M. Humphry's *Observations on Myology,* Cambridge, 1872, the morphology of the muscles of the limbs is considered.

COMPARATIVE ANATOMY.

Quadrumana.—E. H. Giglioli publishes (*Ann. del Museo Civico di Storia Nat. di Genova,* Dec. 1872) Craniological studies on the Chimpanzee. He describes a new species by the name of *Troglodytes Schweinfurthii.*——R. Hartmann continues (*Reichert und du Bois Reymond's Archiv,* 1872, 474) his observations on the *anatomy of the anthropoid apes,* and considers the cranium of the Chimpanzee.——Paul Broca studies (*Revue d'Anthropologie,* I.) the constitution of the caudal vertebræ in the Primates without tails. He considers that the tail may disappear after three different ways; in one the defect in development is due to a proportional atrophy in the true and false segments of the caudal apparatus, and is seen in *Cynocephalus, Nycticebus* and *Loris:* in the second it proceeds from the free end towards the base, as in the *magot:* in the third in a modification in the first segment much more than in the terminal segment. Here the first segment is fused with the sacrum to form a supplementary sacrum, whilst the terminal segments remain mobile and constitute the coccyx; this type is found in man and the anthropoids.——Jas. Murie gives some observations (*Proc. Zool. Soc.* June 18, 1872) on the *Bornean ape.* He figures both the pelvis and the cranium.

CARNIVORA.—Jas Murie describes some anatomical features (*Proc. Zool. Soc.* June 4, 1872) of the Indian Wild Dog, *Cuon primævus.* He figures the head, soles of the feet, cæcum and anal region of this animal.——From a dissection of two specimens of the Two-spotted Paradoxure (*Nandinia binotata*) W. H. Flower has been able to show (*Proc. Zool. Soc.* June 4, 1872) that this animal is destitute of a cæcum. It differs from all known Carnivora in the persistence throughout life of the cartilaginous condition of the posterior chamber of the auditory bulla.

PINNEPEDIA.—Robert Walker records (*Scottish Naturalist*, 1873) the capture of a specimen, 22nd July, 1872, of the hooded seal, *Cystophora cristata*, at St Andrews.——J. E. Gray gives an account (*Proc. Zool. Soc.* May 21, 1872) of the New Zealand Sea Bear (*Arctocephalus cinerius*), and the North-Australian Sea Bear (*Gypsophoca tropicalis*).

CETACEA.—W. H. Flower has given (*Trans. Zool. Soc.* 1871) a description of the skeleton of *Berardius arnouxi*, with an introductory chapter on the recent ziphioid whales. He defines the common characters of the group, and then describes the special characters of the genera *Hyperoodon, Ziphius, Mesoplodon* and *Berardius.* The memoir is illustrated by three large plates representing the skeleton of *Berardius.*—J. E. Gray publishes (*Ann. Nat. Hist.* Jan. 1873) a short criticism on Prof. Flower's memoir on *Berardius* and other Ziphioid whales.—H. J. Carter notes (*Ann. Nat. Hist.*, March, 1873) the presence of the *Sperm Whale* in the Indian Ocean just within the Tropics.—In the Feb. number of the same *Annals*, J. E. Gray notes the *geographical distribution, migration, and occasional habitats* of Whales and Dolphins: and on p. 104 Jas. Hector notes the Whales and Dolphins which frequent the New Zealand Seas, viz.: *Neobalæna marginata, Eubalæna australis, Megaptera novæ-Zealandiæ, Physalus australis, Catodon macrocephalus, Delphinus novæ-Zealandiæ* and *Forsteri, Electra clancula, Pseudorca meridionalis, Grampus Richardsoni, Beluga Kingii, Globio-cephalus macrorhynchus, Epiodon chathamiensis, Mesoplodon Layardii, Berardius Hectori* and *Arnouxii.* Dr Gray appends some remarks to Dr Hector's paper. On p. 159 J. E. Gray states that *Orca stenorhyncha* has been found at Bohuslän in Sweden. On pp. 157 and 238 W. H. Dall describes parasites which infest the cetacea of the N. W. Coast of America. He refers them to the following species, *Cyamus Scammoni, suffusus* and *mysticeti, Coronula balænaris,* and *diadema?, Crypto-lepas rhachianectis,* and *Otion Stimpsoni.* W. H. Dall also gives a preliminary description (*Ann. Nat. Hist.* April, 1873) of three species of Cetacea, said to be new, from the coast of California: he names them *Delphinus Bairdii, Tursiops Gillii* and *Grampus Stearnsii.* In the same *Annals*, Dec. 1872, is a translation of H. Burmeister's memoir on *Balænoptera patachonica* and *intermedia*, and a description by C. M. Scammon of a species of *Balænoptera* which he names *B. Davidsoni.* J. E. Gray also proposes the name of *Epiodon Heraultii* for one of the specimens of Ziphioid whales which has been described.——Jas. Murie gives (*Trans. Zool. Soc.* VIII.) a long memoir on the *organisation of the Caaing Whale, Globiocephalus melas,* which is illustrated by nine beautifully executed plates and several wood-cuts. The various organic systems, except the osseous and nervous, are described.——J. Reinhardt (*Vidensk. Meddel. fra den naturh. Forening i Kjöbenhavn,* 1872) makes some observations on *Pseudorca Grayi.* He does not think that any appreciable difference exists between it and *Ps. crassidens,* though he distinguishes many points in which it differs from *Ps. meridionalis* (Report, VII. 173). With reference to the large dolphins observed by Burmeister in 1850, in the Atlantic, Reinhardt considers that the form of the dorsal fin is somewhat in favour of the opinion that they were *Pseudorcæ* rather than true *Globio-cephali.*——E. W. H. Holdsworth notes (*Proc. Zool. Soc.* April 16, 1872) a Cetacean observed on the West Coast of Ceylon, which was characterized by the presence of a dorsal fin estimated to be not less than five feet high, which stood erect on the highest part of the back, and was shaped like the pointed end of an ordinary sword, with the anterior edge slightly convex and the posterior straight.——P. Gervais records (*Journ. de Zool.* I. 537) the capture of the carcase of a male Cachalot in a state of putrefaction near Biarritz in November, 1872; and, on p. 323, after giving copious extracts from the Reporter's memoir on the placentation of the Cetacea (Report, VI. 469), Gervais refers to a fœtus which he had extracted from the uterus of *Delphinus delphis,* and he figures the fœtus both inclosed within the membranes and after removal from them. On p. 274 of the same vol. P. Fischer describes two species of *Globio-cephalus, G. macrorhynchus* and *G. Edwardsi.*

SIRENIA.—P. J. van Beneden communicates (*Bull. Acad. R. Belgique,* XXII. 205) observations on the *Osteology of the Dugong and Manatee.*——F. Krauss (*Reichert u. du Bois Reymond's Archiv,* 1872, 257) gives an elaborate description with figures of the *pelvic bones of the Manatee* from Surinam. He had received a number of specimens, both male and female, some of which had the muscles still attached.——Jas. Murie furnishes (*Trans. Zool. Soc.* VIII.) an important decription of the *form and structure of the Manatee.* The memoir occupies 75 quarto pages, and is illustrated by 10 large plates, in which the external characters, muscular system, alimentary canal, the brain, the pulmonary and generative organs, and the great vascular plexuses, are figured.

ARTIO-DACTYLA.—J. Alex. Smith collects together (*Proc. Scot. Soc. Antiq.* IX.) a number of facts concerning the remains of the Elk, *Cervus Alces,* found in Britain, and notes some instances of the discovery of the remains of *Megaceros hibernicus* in Scotland.——John W. Clark notes in *Proc. Zool. Soc.* Feb. 20, 1872, a number of observations on the *visceral anatomy of Hippopotamus.* He figures the tongue, larynx, trachea and uterus.

DINOCERATA.—O. C. Marsh communicates additional particulars (*Americ. Journ. Science and Arts*, Feb. 1873) on the very remarkable horned fossil mammals, the remains of which have recently been discovered in the Eocene beds of Wyoming. Three pairs of horn cores are found on the cranium, viz. on the nasals, the maxillaries, and the great crest formed by the parietals and supra-occipitals. Although the vertebræ and limb-bones are in many respects like the Proboscidea, yet the cranial characters are so distinctive as to render it necessary to constitute a new order for these mammals.

MARSUPIALIA.—Alex. Macalister describes and figures (*Proc. Zool. Soc.* March 19, 1872) the cranium of the Broad-headed Wombat (*Phascolomys latifrons*).

BIRDS.—W. K. Parker describes (*Monthly Mic. Journ.* Jan. and Feb. 1873) the development of the SKULL IN THE TIT AND SPARROW-HAWK, and in March the development of the SKULL IN THE GENUS TURDUS.——A. H. Garrod and F. Darwin give (*Proc. Zool. Soc.* March 5, 1872) some anatomical particulars of an OSTRICH which lately died in the Zoological Gardens.——O. C. Marsh records (*Amer. Journ. Science and Arts,* Feb. 1873) some observations on a new sub-class of fossil birds (ODONTORNITHES). The type species, *Ichthyornis dispar,* has well-developed teeth in both jaws, which are numerous, compressed, pointed and implanted in distinct sockets. In the lower jaw about 20 in each ramus, and apparently about the same in the upper. The jaws did not seem to have had a horny sheath. Vertebræ biconcave; bones of extremities conform to ornithic type. He believes that he can distinguish more than one genus, and that the discovery of these fossils does much to break down the old distinctions between birds and reptiles.——Jas. Murie communicates (*Proc. Zool. Soc.* May 21, 1872) observations on the OSTEOLOGY OF TODUS, and on June 18 he describes the CRANIAL APPENDAGES and wattles of the Horned Tragopan (*Ceriornis satyra*); whilst in *Ibis,* Oct. 1872, he discusses the MOTMOTS and their affinities. From an examination of the anatomy of the Huia Bird (*Heteralocha gouldi*) A. H. Garrod (*Proc. Zool. Soc.* May 21, 1872) concludes that it is truly Passerine, and not related to Upupa, as had previously been supposed.——In a paper on the mechanism of the Gizzard in Birds (*Proc. Zool. Soc.* April 16, 1872), A. H. Garrod states that the food is thrust between the lateral muscles by the contraction of the superior and inferior gizzard sacs—upon which these lateral muscles contract simultaneously; and their arrangement is such that all the force of their contraction is converted into a compressing force at right angles to their direction.

REPTILIA.—J. E. Gray enters (*Ann. Nat. Hist.* March, 1873) into the consideration of the original form, development and cohesion of the bones of the STERNUM OF CHELONIANS, with notes on the Skeleton of *Sphargis.*——Paul Gervais extracts, in *Journ. de Zool.* 1873, II. from his memoir in *Nouv. Archives du Muséum,* VIII. some observations on the OSTEOLOGY of the SPHARGIS LUTH.——A detailed description of the MYOLOGY of LIOLEPIS BELLI is given by Alfred Sanders in *Proc. Zool. Soc.* Feb. 6, 1872.——L. A. Segoud completes (*Robin's Journ.* No. 1, 1873) a memoir on REPTILES AND BATRACHIANS, classed in five types, based on the configuration of fundamental parts of the skeleton.——F. Leydig describes (*Schultze's Archiv*, 1872, IX. 1) the STRUCTURE AND DEVELOPMENT OF THE TEETH OF THE SNAKES indigenous to Germany.

FISH.—In our Report, VI. 447, an account is given of Ercolani's observations on PERFECT HERMAPHRODITISM IN THE EEL. He has now published some additional considerations on the same subject in *Ann. dell. Soc. dei Natur.* Modena, 1872. An abstract of Ercolani's memoir, and of one on the same subject by G. Balsamo-Crivelli and L. Maggi, is in *Robin's Journ.* No. 1, 1873.——Joseph Hyrtl describes and figures (*Denk. der Kaiser. Akad. der Wiss.* Vienna, 1872) the *cranial arteries* and the arrangement of the *vascular arches* in the SHARKS.——P. Legouis communicates (*Ann. des Sc. Nat.* 1873, XVII. 17) an elaborate memoir on the PANCREAS OF OSSEOUS FISH and the TUBES OF WEBER. He writes a historical introduction in which he gives an interesting description of the observations made at different times to show the co-existence both of pyloric cœca, and of a pancreas in the osseous fish; he relates also Weber's observations on a tube entering the intestine which was not a bile-duct. He then proceeds to point out the general presence of Weber's tubes, the general presence of a pancreas, the relation of the pancreas to Weber's tubes and to the viscera, more especially the liver. He concludes with some observations on the lymphatic organs. ——Th. Gill states his views (*Ann. Nat. Hist.* March, 1873) on the homologies of the *Shoulder Girdle* of the *Dipnoans* and other fishes. ——R. Walker describes (*Trans. Geol. Soc. Edin.* II.) a new species of *Amblypterus*, which he names *Am. Anconoæchmodus*, obtained from the shale worked for the distillation of paraffine oil at East Pitcorthie, Fife.——R. H. Traquair describes (*Roy. Geol. Soc. Ireland*, Dec. 6, 1871) specimens of *Phaneropleuron Andersoni* and *Uronemus lobatus.*

INVERTEBRATA.—E. Ray Lankester communicates (*Ann. Nat. Hist.* Feb. 1873) observations on the *development* of *Loligo*, *Aplysia*, of various *Nudibranchs*, of *Terebella nebulosa*, together with observations on points in the anatomy of *Appendicularia*, *Sipunculus*, *Sternaspis*, *Glycera*, *Terebratula*, *Phyllirhöe*, *Pyrosoma* and *Dicyema.*——L. Cienkowski makes some observations (*Schultze's Archiv*, IX. 47) on *Noctiluca miliaris.*——In an important memoir on the *Anatomy of Limulus* (*Ann. des Sc. Nat.* 1872) Alph. Milne Edwards describes the vascular, nervous and appendicular system of this animal. The memoir is illustrated by twelve beautiful plates, several of which are coloured.——A. S. Packard gives an account (*Mem. Boston Soc. Nat. Hist.* II.) of the DEVELOPMENT OF LIMULUS POLYPHEMUS, and to *Mem. Peabody Acad. Sc.* 1871, the same anatomist communicates EMBRYOLOGICAL STUDIES on *Diplax Perithemis*, *Isotoma*, and in same *Memoirs*, 1872, embryological studies on HEXAPODOUS INSECTS.

REPORT ON THE PROGRESS OF PHYSIOLOGY. By WILLIAM RUTHERFORD, M.D., F.R.S.E., *Professor of Physiology, King's College, and Fullerian Professor of Physiology, Royal Institution, London*[1].

Nervous System.

BRAIN.—*The Principles of Psychology.* By Herbert Spencer. Second Edition. London: Williams and Norgate. See an article on this by Douglas A. Spalding (*Nature*, Vol. VII. p. 298). *Hereditary Genius.* By Francis Galton. Macmillan and Co. On Darwin's Philosophy of Language. By Max Müller (*Nature*, Vol. VII. p. 145). He criticises the evolution theory in so far as it is by some regarded as accounting for the origin of languages, and maintains that between the language of man and that of the lower animals there is *no* natural bridge, and that to account for human language such as we possess, would require a faculty of which no trace has ever been discovered in lower animals. Darwin admits that articulate language is peculiar to man, but contends that animals have, in a lower stage of development, the identical faculties necessary to the invention of articulate expressions. Müller replies that no development of mental faculties has ever enabled any animal to connect one single definite idea with one single definite word. There is an essential difference between the expression of emotions and the expression of ideas and abstract conceptions. There is no evidence that mere conditional signs and sounds can develope into articulate speech. Both man and the lower animals possess emotional, but man alone possesses rational language. The latter is to be traced back to roots. Every root is the sign of a general conception or abstract idea of which the lower animal is incapable. Darwin has stated that there are languages which have no abstract terms, but Müller maintains that the names of common objects, e.g. father, mother, &c. are abstract terms. Rational language is the true barrier between man and beast.

THE CAUSATION OF SLEEP.—By James Cappie, M.D. pp. 76, Edinburgh, James King. For an abstract, see *London Medical Record*, 1873, No. 9. Dr O'Dea (*Quarterly Journal of Psychological Medicine*, No. III.) regards dreams as the "present mental images of past sensations revived by the subjective states of the dreamer, or by the objective impressions on his senses. The principal factors of dreams are, (*a*) bodily sensations, whether these be subjective or objective, and

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[1] Owing to the short notice in which I have been asked to prepare this Report I am obliged to give merely the titles of many papers, and to refer the reader to abstracts in other periodicals.

To assist in rendering this report complete, authors are invited to send copies of their papers to

King's College, Strand,
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(*b*), our previous waking thoughts, dispositions and prevalent states of mind." H. Quincke (Physiology of the Cerebro-spinal Fluid, *Reichert's Archives,* 1872, p. 158) injected an emulsion of cinnabar into the subarachnoid space of the spinal cord in the region of the first lumbar vertebra of the dog. After the lapse of a period, varying in different instances from one week to three months, he found the cinnabar in the subarachnoid tissue and pia of the *brain* as well as the spinal cord. In ten out of twelve cases it was much accumulated at the base of the brain. It was found around all the cranial and spinal nerves, especially where they pierce the dura mater. In a number of cases it extended for some distance along the nerves—especially in the case of the optic, where it penetrated as far as the eye-ball. It was also found in the cervical lymph glands. It was not found in the proper substance of either the brain or spinal cord. In a second series of experiments the cinnabar emulsion was injected into the special arachnoid cavity of the cranium. In a few days it had largely disappeared from this, and was found in the subarachnoid spaces and pia of the brain exactly as after direct injection into these parts. It was also found in the spinal canal. From these experiments Quincke concludes, 1, that there is a connection between the subarachnoidal spaces of the brain and spinal cord. 2. During life there is a current in the subarachnoid fluid from behind forwards as well as in an opposite direction (the pigment passed in both directions). He thinks that the respiratory motions of the subarachnoid fluid (Magendie) are the most probable cause of the diffusion of the *precipitated* particles of the cinnabar. 3. The passage of the cinnabar from the arachnoid cavity of the brain into the subarachnoid spaces of brain and cord shows that these parts communicate. 4. The apertures of exit for the cerebro-spinal fluid appear to be indicated by these experiments. There seem to be channels in connection with the nerves through which the fluid escapes. This appears to be the explanation of the presence of free cinnabar particles and also of lymph corpuscles containing cinnabar in these situations. The pacchionian bodies appear also to be places of exit. These were strongly pigmented. The cinnabar was never found in the central canal of the spinal cord, the "perivascular spaces" of brain or cord, the lymph-vessels of the olfactory membrane, in Tenon's space or the perichoroidal space, which, according to the injection experiments of Key, Retzius and Schwalbe, communicate with the arachnoid space. Quincke concludes that normally these parts discharge their fluid into the subarachnoid space, and receive nothing from this.

Fournié.—*Recherches Expérimentales sur le Fonctionnement du Cerveau.* 8vo. Paris. Delahaye.

"On Instinct," by Mr Douglas Spalding (*Macmillan's Magazine*, February, 1873). (Abstract in *Lancet,* 1873, March 1st.) Also a paper by Lewes with reference to this in *Nature.* 1873, April 10.

"On the Anatomical and Physiological Localisation of Movements in the Brain. Excellent lectures by Dr Hughlings Jackson." (*Lancet,* Vol. I. 1873, pp. 84, 164, 232.)

SPINAL CORD.—The present teaching regarding conduction in the spinal cord, may be briefly stated to be this. Sensory impressions are conducted by the grey matter, especially near its central part. Motor impressions are conducted by the anterior and lateral columns and to some extent by the anterior horn of grey matter. Section of the posterior column produces hyperæsthesia on the same side for impressions which give rise to pain, and the posterior columns seem to be concerned in the co-ordination of movements. These conclusions are chiefly based upon Brown-Séquard's experiments. Schiff (*Centralblatt*, 1872, p. 774) states that he formerly ascertained, and Longet confirmed his statements—that the posterior columns of the cord conduct only tactile impressions, and not those which give rise to pain, or those which result from pressure ("nicht aber für die Schmerz und Druckempfindungen")—a fact which agrees with neuropathological experience of cases [of tabes dorsalis] in which painful sensation remains while tactile sensation is lost. Hence, if the spinal cord be divided transversely, so as to leave only the posterior columns, the tactile sense remains while the sense of pain is abolished. Recently Schiff has improved his operative method so that he can perform the experiments with very slight loss of blood, and without producing death. In these experiments he divided only the posterior columns of the cord, or one of these together with a portion of the lateral column, or the grey matter, or the anterior column. At first the symptoms were mixed, but after a few days all the other functional disturbances disappeared with the exception of the loss of the tactile sense, which was permanent. The autopsies showed that the partial recovery could not be ascribed to any reunion of the divided parts. Schiff maintains that with the exception of the posterior columns lesions of almost all other parts of the cord may be compensated for by the portions which remain intact. The only exception to this "rule" is the case of the posterior columns: "every" lesion of these columns produces a permanent loss of tactile sense, which is not compensated for by any other part of the cord. In tabes dorsalis, where the loss of tactile sense is the most common symptom, the autopsy may show a degeneration limited to the posterior columns or extending beyond these, and yet the symptoms are almost the same as they are when the posterior columns only are affected. It would almost appear as if with the exception of the posterior columns the other portions of the cord have no definite function. The fact that the tactile sense may be much impaired when there is an extensive degeneration of the lateral column with but slight affection of the posterior column, has led some to believe that the posterior column is not the only part which conveys tactile impressions. Schiff considers the true explanation to be this, a lesion of the posterior column is not compensated for, but there is compensation in the case of lesions occurring elsewhere. The application of this rule must however be limited. It holds good for the dorsal and for the lower part of the cervical portion of the cord (that opposite the three lower cervical vertebræ and extending down to the eleventh dorsal vertebra); above and below these points the rule requires modification. Sanders-Ezn previously found that in the lumbar portion and in the lower dorsal part of the cord the tactile sensory fibres do not enter the posterior columns transversely, but that they pass obliquely upwards and join the posterior columns from 6—9 cm. ($2\frac{1}{2}$—$3\frac{1}{2}$ inches) above the nerve-root. So that the tactile nerves of the posterior extremities traverse the cord without entering the posterior columns until they reach as high as the last but one or the last but two of the dorsal vertebrae (dog, rabbit). The posterior columns of the lumbar portion of the cord contain, however, the tactile nerves of the organs of generation, pelvis, anus and tail. The tactile nerves of the feet lie in yet other regions of the cord. Schiff argues with Sanders-Ezn, and further shows that injury to the lateral columns of the lumbar portion of the cord has, in relation to the posterior extremities, the same result as lesion of the posterior columns in the dorsal and lower cervical portion of the cord. The paths of tactile impressions change their position in the lower part of the cord, but not their character. Ataxia of the lower extremities may be associated with a degeneration of the lumbar portion of the cord which does not affect the posterior columns. In such a case, the tactile sense is still present in the anal region. The converse holds true when the posterior columns are degenerated in the lumbar regions. Still more important and interesting is the modification of the rule regarding the posterior columns, which applies to the part of cord above the third cervical vertebra. Here, there is in the lateral column a tract of white substance which serves for the conduction of the respiratory motor influences. A lesion of this tract produces an absolute and permanent palsy of respiratory motion. In this case, as in that of the tactile fibres of the posterior columns, there is no compensation such as obtains for the other motor fibres of the cord. The lateral columns of the cord between the third lowest cervical and the lowest but one dorsal vertebra, are not the conductors of impressions which give rise to a sense of pain on pressure in the posterior extremities. These are conveyed by the central and lateral grey matter. While the posterior columns conduct the tactile impressions, the lateral grey substance of the *right* side in dogs and also in man is the special, and, it may be, the only conductor of painful impressions from the *left* posterior extremity, and *vice versa*. In cats, however, there is an exception. Here, the sensory tracts do not decussate as in man and in the dog, but the grey substance conducts the painful impressions produced on the same side of the body. It is worthy of remark, that in all these experiments Schiff found the parts which convey painful impressions quite insensible to direct stimulation.

CHORDA TYMPANI.—Vulpian (*Gazette Médicale*, Feb. 15, 1873) has discovered that if the chorda tympani be divided in the dog and its peripheral cut end stimulated, there is not only dilatation of vessels in the submaxillary and sublingual glands, *but also in the mucous membrane of the lateral half of the tongue on the same side.* There is no motion of the tongue, nor any increase of secretion from its mucous membrane. As is well known, the salivary glands abovementioned secrete when the nerve is thus stimulated. As is now known, this secretion is coincident with, but not dependent upon, the vascular dilatation (see *Journal of Anatomy and Physiology*, No. XI. p. 199). Vulpian has also shown that the chorda contains centripetal excito-secretory as well as centrifugal secretory fibres. The former convey their impressions to the secretory centre in the brain. (For a fuller abstract of these researches, see *London Medical Record*, 1873, No. 17.)

By the Wallerian method of investigation, Prevost (*Comptes Rendus*, LXXV. 1872, p. 1828) has traced the chorda tympani to the tongue. In dogs, cats, rats, and guinea pigs, he divided the chorda, and from 6—10 days afterwards examined the terminations of the lingual nerve. In all cases, he found degenerated fibres; he also observed degenerated fibres in the mucous membrane at the point of the tongue. He remarks that the microscopical examination of the nerve should not be delayed for more than 10—12 days after the section of the chorda, because the granular matter resulting from the degenerated white substance of Schwann is, especially in young animals, speedily absorbed. [Possibly this is the explanation of Vulpian's inability to find these altered fibres after section of the chorda, some years ago.]

VAGUS. Legros and Onimus, "Experimental Researches on the Physiology of the Pneumogastric Nerves," *Robin's Journal de l'Anatomie*, 1872, p. 411. This paper contains a number of facts which had been previously ascertained.

INFLUENCE OF THE VAGUS ON CONVULSIONS.—Brown-Séquard (*Archives de Physiologie*, 1872, No. 2, p. 204) finds that a strong stream of CO_2 through the throat or larynx can cut short an epileptic attack in guinea pigs whose sciatic nerve or lateral half of the spinal cord has been divided. He confirms Rosenthal and Leube's experiments on the arrest of strychnia convulsions by an apnœic condition of the animal [that is, by a *hyperoxygenated* condition of the blood], but suggests that the result is not due to apnoea but to mechanical irritation of the endings of the vagus in the respiratory mucous membrane, by the rapid inflation of the lungs adopted in these experiments; section of the vagi prevents the arrest of the convulsions in such a case. A stream of CO_2 directed against the laryngeal mucous membrane, arrests the respiratory motions, as well as strychnia convulsions; moreover, in the case of birds after ligation of the large cervical vessels, the convulsions were still arrested when the stream of CO_2 was directed against the mucous membrane of the bronchi and that of the lower larynx. He therefore considers that the CO_2 is a powerful irritant of the terminations of the vagus, and that it reflexly arrests convulsions due to epilepsy, strychnia, or anæmia.

TROPHIC NERVES.—On this subject see an article in *British Medical Journal*, 1872, Aug. 31, giving a résumé of Fischer, Schiefferdecker, Joseph and Vulpian's researches regarding the influence of nerves on nutrition. (Abstracts of these papers will however be found in

Journal of Anatomy and Physiology, Vols. VI. and VII.) See also able articles on this question by Mr Henry Power (*The Practitioner*, Feb. and March, 1873).

CHANGES IN THE NERVES AFTER SECTION.—See Dr Pye-Smith's abstract (*London Medical Record*, Vol. I. p. 198) of a remarkable communication to the Académie des Sciences by Ranvier, in which he states that the so-called degenerative changes in the distal portion of a divided nerve "are, as far as the cellular elements are concerned, rather those of hyperplasia: the removal of nervous influence apparently allowing more unrestrained activity." [It will be necessary to subject this point to careful scrutiny ere a conclusion so novel and so opposed to our present views can be accepted.]

GENERAL PHYSIOLOGY OF NERVE.—Setschenow "on the Behaviour of Nerves during Rapid Irritation" (*Pflüger's Arch.* 1872, p. 114, also Bernstein (*Ibid.* p. 318) abstract in *Centralblatt*), W. Filehne, "The Law of Contraction in Dying Nerves" (*Centralblatt*, 1872, p. 889).

The Senses.

SKIN. SENSORY NERVES FOR TACTILE AND PAINFUL IMPRESSIONS.—The idea that the cutaneous sensory nerve apparatus concerned in the reception and transmission of tactile impressions differs from that which receives the impressions that give rise to pain, apparently receives support from observations on "cold anæsthesia," by Horvath (*Centralblatt*, 1873, p. 210). He found that after immersing the finger for some time in alcohol at the temperature of -5°C. he could readily perceive impressions produced by gentle contact of extraneous bodies [tactile impressions], while pricks, which on other fingers produced pain only, gave rise in the chilled finger to a sensation of touch [a tactile sensation].

EYE.—Holmgren, "On Förster's Perimeter and the Topography of the Sense of Colour" (*Centralblatt*, 1872, p. 823). J. Fränkel, "The Apparatus for Accommodation in the Human Eye" (*Centralblatt*, 1872, p. 858). Dr R. J. Lee, "Further Remarks on the Sense of Sight in Birds" (*Proc. Roy. Soc.* 1873, January 9). Leber, "Condition of the Circulation in the Optic Nerve and in the Retina" (*Graefe's Archiv für Ophthalmologie*, XVIII. No. 2). Mandelstamm, "Association of the two Retinæ" (*Ibid.*). Samelssohn, "Innervation of the Ocular Movements" (*Ibid.*). F. C. Donders, "On Congenital and acquired Association" (*Ibid.*). Dobrowlsky, "A number of short Papers on the Perception of Colour" (*Ibid.*). Exner, "On the Physiological Action of Iridectomy" (Abstract in *Centralblatt*, 1873, p. 17).

EAR.—Bœttcher, "Critical Annotations and New Contributions to the Literature of the Labyrinth of the Ear" (Monograph). He treats of the structure of the Lamina Spiralis and details experiments which refute the idea entertained by Flourens and Goltz, that the semicircular canals are concerned in maintaining the balance of the body. (See an abstract by Mr Ernest Hart in the *London Medical Record,* 1873, p. 110.)

Circulatory System.

Blood Coagulation.—Alexander Schmidt ("New Researches on Coagulation of Fibrin," *Pflüger's Arch.* 1872, p. 413. Abstract in *Centralblatt,* 1873, p. 22) modifies his well-known account of the coagulation of the blood. Fibrinogen and fibrinoplastic substance constitute the material from which fibrin is produced. The quantity of fibrin increases with the quantity of either of these constituents—it matters not which—within certain limits. But for the production of fibrin from these substances, a third body, *a ferment,* is necessary in order to bring about the union of the fibrin-generators. He designates this "Fibrin ferment." 1. A small quantity of this produces in the same fluid as complete a fibrin formation as a large quantity, only not so rapidly. 2. The activity of the fibrin ferment, indicated by the rapidity of coagulation, increases with the proneness to coagulation, and attains its maximum at the temperature of the body. It is destroyed by the temperature of boiling water, on the other hand it is rendered inactive by a freezing temperature. 3. If one filter off the serum in which a clot has been formed by the action of the fibrin ferment, the filtrate can (although not so energetically) anew call forth coagulation in a fluid containing fibrinogen and fibrinoplastin. All the animal fluids which coagulate, contain fibrinogen and fibrinoplastin, *but no ferment.* This first appears after removal of the fluid from the body, rapidly in the case of blood, slowly in that of the transudations. [If the coagulation be due to this ferment, then, under certain circumstances it must be admitted that it can arise within the body.] The ferment may be obtained by precipitating blood serum with from 15—20 times its bulk of strong alcohol. Let stand for fourteen days, filter, dry the precipitate over sulphuric acid, powder it and extract it with cold water. For the activity of the ferment it matters not whether serum or blood be taken. No ferment can be obtained from the blood allowed to flow from a vein into alcohol, because the ferment is not preformed in the blood. The fermentative activity is the greater the longer the time between the removal of the blood from the body and its precipitation by alcohol. The accumulation of the ferment reaches its maximum however with the completion of the coagulation of the blood. After this period there is no further formation of ferment. Lowering the temperature to 0°C. retards the formation of ferment, but does not entirely prevent it. Schmidt is convinced that neither the coloured nor the colourless corpuscles take part in the origin of the fibrin ferment. If the solution of the fibrin ferment and that of the fibrin generators be treated for some time with CO or H, no coagulation follows their admixture. If however the fluids be removed from the action of these gases and exposed to the air, coagulation sets in. The presence of O therefore appears to be necessary for the coagulation. If to a fluid containing fibrinogen and ferment fibrinoplastic substance be added, it is found that a certain quantity is necessary to use up all the fibrinogen in the fluid, in order to produce fibrin. When all the fibrinogen is removed, the further addition of fibrinoplastic substance to the fluid causes no further separation of fibrin. The amount of fibrin formed does not increase with the quantity of the fibrin ferment, the rate of the formation is alone increased by this. The blood pigment or the coloured corpuscles accelerate the appearance of coagulation. (Schmidt withdraws his former statement that the blood corpuscles are rich in fibrinoplastic substance.) In doing so it does not appear to undergo any change, for the same quantity can again and again induce coagulation. The blood-pigment shares this peculiar power with carbon, platinum, asbestos, animal ferments, and all bodies which can destroy hydric peroxide and use its oxygen. The fibrin ferment differs from other ferments in the fact that it is unable to destroy hydric peroxide. Schmidt is now inclined to regard the influence of these bodies on coagulation as an action due to mere contact, and not, as he formerly supposed, to the influence of oxygen condensed on their surface.

HÆMOGLOBIN.—See *Proc. Roy. Soc.* 1872, Dec. 12, for a valuable paper by Mr E. Ray Lankester on Hæmoglobin. In addition to numerous original observations, he gives a valuable summary of the facts which have been ascertained regarding the distribution of Hæmoglobin in various animals. Müller, "Action of Quinine in Hæmoglobin." Inaug. Dissert. Bonn, 1872. (Abstract in *Centralblatt*, 1872, No. 40.)

CARBONIC OXIDE HÆMOGLOBIN.—Zuntz (*Pflüger's Archiv*, v. p. 584) finds that carbonic oxide Hæmoglobin is not so stable a compound as has been imagined. The CO is removed by placing the HbCO in a vacuum, and the remaining Hb shows the spectrum of ordinary reduced Hb. He infers from this fact, that artificial respiration should be energetically employed in CO poisoning. See also an abstract of Podolinski's researches on this subject (*London Med. Record*, 1873, p. 70).

BLOOD CORPUSCLES.—Abstract of a paper by M. Malassez (in *London Med. Record*, 1873, No. 1), "On the number of the blood-corpuscles in mammals, birds and fishes."——Geltowski, "On the action of Quinine on the colourless blood corpuscles" (*Practitioner*, 1872, p. 321).

IRON IN THE BLOOD AND FOOD.—Boussingault. (For abstract, see *Journal of Chem. Soc.* Sept. 1872.)

INORGANIC CONSTITUENTS OF BLOOD.—Janisch. (For abstract, see *Ibid.*)

NEW TEST FOR BLOOD.—Sonnenschein, "Action of a New Reagent on Blood and its employment in Forensic Medicine" (*Centralblatt*, 1872, No. 54).

BLOOD GASES.—See abstract of a paper by M. Lepine (in *London Med. Rec.* 1873, No. 13). Mathieu and Urbain (*Brown-Séquard and

Vulpian's Archives, 1872, p. 190) investigate the amount of gas in the blood of different arteries. See Mr Power's abstract in *Brit. and For. Med.-Chi. Rev.* Oct. 1872, p. 524.——Wolffberg, "Tension of the Blood gases in the Pulmonary Capillaries," *Pflüger's Archives*, IV. p. 465 (abstract in *Centralblatt*, 1872, No. 1).——Wolffberg, "On Pulmonary Respiration" (*Pflüger's Archives*, 1872, p. 23).——Strassburg, "On the Topography of the gaseous tensions in the Animal Organism" (*Ibid.* p. 65).——Pflüger, "On the Diffusion of Oxygen, the Seat and the Laws of the Oxidation Processes in the Animal Organism" (*Ibid.* p. 43). Abstract of the last three papers (in *Centralblatt*, 1872, No. 40, and in *Brit. and For. Medico-Chi. Rev.* April, 1873).

ESTIMATION OF THE ABSOLUTE QUANTITY OF BLOOD.—Steinberg (*Pflüger's Archives*, 1873, p. 101), "Minute Moving Particles as Constant Constituents of Normal Human Blood" Nedsvetzki (*Centralblatt*, 1873, No. 10).

INNERVATION OF THE HEART.—For abstract of recent researches by Schiff, see *Centralblatt*, 1873, Nos. 1, 2, 3, and *British Med. Journal*, 1873, March 8. He denies the existence of accelerating nerves for the heart in the cervical sympathetic and cervical portion of the spinal cord, and maintains that the only accelerating nerves are derived from the spinal accessory. They join the vagus, but afterwards leave this nerve at the ganglion of the trunk passing in the pharyngeal or superior laryngeal nerves to the recurrent laryngeal through which they pass down the neck to the heart. [Schiff no doubt expects to hear something about this from those who have furnished him with the ideas which have led him to the conclusion regarding which we are for the present silent.]

"REFLEX RELATIONS BETWEEN THE STOMACH AND THE NERVE-CENTRES FOR THE ORGANS OF CIRCULATION."—*Centralblatt*, 1873, No. 13.

INNERVATION OF THE VESSELS OF THE RABBIT'S-EAR.—Moreau. *Brown-Séquard and Vulpian's Archives*, IV. p. 667.—Abstract in *Centralblatt*, 1873, No. 15.

Respiratory System.

INFLUENCE OF RESPIRATION ON BLOOD-PRESSURE.—The respiratory curves in the blood-pressure have been generally ascribed to the mechanical influence of the thoracic movements. Schiff (*Centralblatt*, 1872, No. 48) admits that with exaggerated respiratory motions, such as those seen after division of the vagi, a mechanical effect upon the blood-pressure, e.g. in the carotid is evident, but maintains that in normal respiration the respiratory oscillations of the blood-pressure are due to rhythmical excitation of the vaso-motor centre in the medulla, causing periodic rises in the blood-pressure by inducing contraction of blood-vessels. The excitement of the vaso-motor centre is according to him due to the same cause as that which excites the respiratory centre, that is, a lessening of the amount of oxygen or an increase in the amount of carbonic acid in the blood. The cause of the ordinary respiratory curves is therefore, according to this theory, not mechanical but chemical. If an animal be caused to breathe pure oxygen the respiratory oscillations become less frequent, so that there may be only one respiratory oscillation in the pressure for three or four respiratory movements. If the blood be saturated with oxygen the respiratory curves in the pressure entirely disappear, although the respiratory movements of the chest be constantly maintained by artificial means. There are some facts which can only be explained with difficulty, or not at all, on the mechanical theory, e.g. at times the respiratory pressure curves are extremely weak, and may even be entirely wanting, and under these conditions a single deep and powerful respiration produces no variation in the blood-pressure. Schiff states that the respiratory curves are wanting, (1) if the interval between two respirations is not great enough to occasion an accumulation of carbonic acid with blood; and (2) if the sensibility of the vaso-motor centre be diminished, the respiratory curves disappear. The first explanation serves for those cases where the respiration is very rapid and the respiratory blood-pressure curves are wanting. The second applies to the case of curarised animals where the respiratory-pressure curves are much diminished in number, and also to the case of animals in which the besoin de respirer is diminished by causing them to breathe for some time an atmosphere rich in CO_2 or poor in O. In such a case the respiratory curves are wanting.

INFLUENCE OF ARTIFICIAL RESPIRATION ON THE CIRCULATION.—From the fact that during ordinary inspiration the intra-thoracic pressure is diminished, whereas, during artificial inflation it is increased, it has been supposed that the effect on the blood-pressure is such as possibly to exert an important influence on the circulation during the performance of experiments in which artificial respiration is adopted. Schiff (*ibid.*) states that the artificial respiration produces no alteration in the mean blood-pressure, although it may give rise to oscillations of the pressure if the inflation of the chest be excessive.

INFLUENCE OF ARTIFICIAL RESPIRATION IN CASES OF CONCUSSION AND COMPRESSION.—Schiff (*ibid.*). See abstract in *London Medical Record*, 1873, No. 1.

RESPIRATORY MOVEMENTS.—"On the Mechanical Conditions of the Respiratory Movements in Man," by Arthur Ransome, M.D. (*Proc. Roy. Soc.* 1872, Nov. 21. Abstract in *London Medical Record*, 1873, No. 1.) See Lectures on Human Myology, by Professor Humphry (*Brit. Med. Journ.* No. 619) for opinions regarding the action of the intercostal muscles. A Pneumograph invented by Prof. Fick. (*Centralblatt*, 1873, No. 13.)

Absorption.

INFLUENCE OF NERVES ON ABSORPTION.—Bernstein "on Goltz's Absorption Experiments" (*Berliner Klin. Wochenschrift*, 1872, No.

28). "On the Relations of the central parts of the Nervous System to Absorption" (*Virchow's Archives*, 1872, LVI. p. 248). Bernstein has repeated the experiments on absorption performed by Goltz (*Journ. of Anatomy and Physiology*, Vol. VI. p. 480), with the slight variation that he removed the heart altogether and tied a cannula in the inferior vena cava. He found the same results as Bernstein: to wit, that in two curarised frogs suspended by the nose, one having the central nervous system intact, and the other having it destroyed, both having neutral salt solution poured through a funnel into the dorsal lymph sac, and both having the influence of the heart upon the circulation suspended (in the case of Bernstein's experiments by removal of the heart). Absorption from the lymph sac readily takes place in the case of the frog with the uninjured central nervous system but not in the other. The evidence of the absorption is furnished by the dropping of bloody fluid from the cannula in the vena cava in the one case and not in the other. Goltz explained this by supposing that owing to vaso-motor palsy in the one and not in the other, the blood-vessels are so dilated that nothing flows through them, and also that nerves proceeding from the central nervous system to the lymph and blood-vessels having the power of causing them to absorb—are paralysed in the one and not in the other case. The fact that electrical stimulation of the frog with the spinal cord and brain accelerated the absorption was ascribed by Goltz to stimulation of the nerves concerned in absorption, just as stimulation of secretory nerves gives rise to secretion. Probably very few persons have cared to adopt an explanation so startling, and having such important bearings, before the advance of less equivocal evidence. Bernstein considers that the conditions of absorption are similar in both cases, but that in the animal with the cerebro-spinal system intact, the blood-vessels contract and so keep up the motion of the blood although slowly. In the frog without the brain and spinal cord the vessels are palsied, hence the blood stagnates and absorption is not facilitated. This explanation is supported by the fact, that if the abdominal blood-vessels be opened in both cases, so that the fluid has to pass from the dorsal lymph sac through a short vascular path, the fluid is absorbed as quickly in the one case as it is in the other.

Heubel ("On the Relations of the Central parts of the Nervous System to Absorption," *Virchow's Archives*, 1872, LVI. p. 248) has been performing experiments on this subject *under the direction of Goltz.* An account of these will be found in the *London Medical Record*, 1873, No. 2. The important feature of his paper is this, that he endeavours to explain such facts as the above by the alteration in the circulation which follows the destruction of the vaso-motor centres in the medulla oblongata and spinal cord, and not by supposing, as Goltz did, that there is a special system of nerves for absorption paralysed in the one case but not in the other. [We may fairly infer from this therefore, that Goltz has retired from the untenable position—in which he asserted that his experiments furnish evidence of the existence of such a system of nerves.]

Alimentation.

Aliment.—Voit "On the Nutritive value of Gelatine" (*Zeitsch. für Biologie*, Vol. viii. Abstract in *London Med. Record*, 1873, No. 3).——Article on Food (*British Med. Journal*, 1872, October 5, 12, and 26).——Carbo-hydrates, and the mode in which they are digested and absorbed; Brücke (*Wiener Sitz. Berich. Math. Nat. Cl.* Vol. lvi. Part iii. Abstract in *London Med. Record*, 1873, No. 3). ——Pettenkofer and Voit "On the Regressive Metamorphosis in Animal Bodies during a Flesh Diet" (*Zeitsch. für Biologie*, 1872, vii. 3. Abstract in *Centralblatt*, 1872, No. 46).——Schenk, "Behaviour of Chlorine in the Organism" (*Centralblatt*, 1872, No. 43).—— F. Hofmann, "Passage of Fat from the Aliment into the Cells of Animal Bodies" (Abstract in *Centralblatt*, 1872, No. 59).——Falck, "On Sodium Chloride" (Abstract in *London Med. Record*, 1873, No. 2).

Innervation of the Œsophagus and Stomach of the Frog.—Goltz ("Movements of the Œsophagus and Stomach in Frogs" *Pflüger's Archives*, 1872, Vol. vi. p. 616), impressed by the difficulties which beset the study of the gastric movements of such an animal as a rabbit, in which the stomach is always full, operated on frogs in the hope that they might furnish results which might serve as a basis for arriving at definite knowledge regarding this matter. He took two frogs which had been starved for some days, poisoned them with curara, removed the heart (so that in both cases irregularities of the circulation might not be encountered), the left lung, the left arm, and laid open the abdomen so that the œsophagus and stomach could be easily seen. In one case the brain and spinal cord were destroyed, in the other these were left intact. Both frogs were suspended by the nose. A solution of Na Cl, $\frac{1}{2}$ per cent. was poured into the mouth in both cases. In the frog possessed of the brain and spinal cord it rapidly found its way into the stomach; but in the other frog it was quite otherwise. The pharynx was contracted, and so the œsophagus and stomach remained quite empty. Nevertheless in this case the gullet and stomach both exhibited somewhat irregular peristalsis, lasting for hours. A similar phenomenon is observed if the activity of the central nervous system be suppressed by the inhalation of chloroform, or by a large dose of curara, or if the vagi be divided. He infers from these facts that the vagi contain inhibitory nerves for the œsophagus and stomach, and that the centre for these fibres is in the central nervous system. The appearance of the peristalsis after division of the vagi, &c. is, according to Goltz, due to palsy of the inhibitory nerves. He found that œsophageal and gastric movements could be induced reflexly in frogs by faradisation of sciatic nerve, or the application of sulphuric acid to the skin. When the application of the irritant is continuous, the movements may last for hours, as after division of the vagi or removal of brain and spinal cord. Goltz therefore thinks that here we have not a reflex action in the ordinary sense, but motion of the parts resulting from a cessation of the action of inhibitory nerves, the irritant producing a temporary palsy of the central ends of the nerves. [But when we remember that section of the vagi produces in higher animals at any rate, palsy of the gullet and partial palsy of the stomach, and that stimulation of the *lower* end causes movement (Goltz even admits that it *intensifies the irregular peristalsis* seen after section of the vagi), it must be maintained that Goltz has not made out his case. There may be in the vagus of the frog *inhibitory* as well as motor fibres, but why the existence of the latter should be ignored we cannot comprehend. To our thinking the point demands further investigation.]

GASTRIC DIGESTION.—Von Wittich, "On the question regarding the Peptic Action of the Pyloric Glands" (*Pflüger's Archives,* Vol. VII. p. 18. See abstract in *London Medical Record,* 1873, No. 10). He considers the pyloric glands to have no peptic action. This conclusion supports the statements of Fick, and Friedinger, &c., and opposes those of Ebstein and Grützner. Wittich's observations were made on the stomach of the pig and rabbit.——Jukes, "Structure of the Peptic Glands" (*Centralblatt,* 1872, No. 47).——Schiff's statement that the energy of gastric digestion is largely dependent on the physiological condition of the animal at the time of observation, e.g. whether there be hunger, digestion, or exhaustion of the gastric wall owing to digestion having been recently going on—although questioned by some authorities—has recently (*Centralblatt,* 1872, No. 50) received additional support from experiments performed by him. Through fistulæ in the stomach of living dogs he introduced known quantities of albumen in muslin bags. He found that when digestion had recently taken place, a much smaller quantity of albumen was digested than was the case when the albumen was introduced into the stomach during normal digestion. Seeing that the proportion of acid and water in the gastric juice, and the temperature of the stomach were the same in both cases, the difference in digestive energy could only be dependent upon the smaller quantity or the less perfect condition of the pepsin. Proceeding from the idea that when the stomach is removed from the body, its digestive power must largely depend upon its condition at the time of death, that is, whether or not digestion had been going on, &c., he—as formerly cut the gastric mucous membrane into small pieces, and made an infusion of it with 100—500 Cm of acidulated water. Into a measured quantity of this infusion a weighed quantity of albumen was placed, and the whole kept at the temperature of the body. After a time the amount of undigested albumen was estimated so that an indication of the digestive power was obtained—sufficient for purposes of comparison. Generally, the amount of albumen digested by the entire stomach in such a case was estimated at 70—100 grammes, in rare cases 150—180 grammes. He finds that the digestive energy depends not only on the amount of pepsin present, but also on other conditions. In order to obtain the entire digestive power of the pepsin, one must carefully ascertain the most suitable quantity of acid and water. The quantity of acid varies in different animals and the amount of acid to be added to the digestive fluid must increase with the quantity of water [that is to say there must be a certain percentage of acid in the fluid]. In experiments with the gastric mucous membrane of a cat, the digestive power increased with the addition of water to the enormous extent of 20—30 litres to the infusion of the single stomach. In this much diluted fluid 2000 grammes of albumin were digested (a single stomach being employed), while in an infusion prepared in the ordinary way not more than 70 grammes are digested. When so much water is employed it is necessary to let the gastric membrane infuse in it for 10—15 days. The amount of acid employed is stated to be the same as that which Schiff in "his former researches found to be the best." The investigation is not yet completed, but he states that for the stomach of a dog 200 litres of water are required to make a suitable infusion, and this can digest 75 kilogrammes of albumen (a kilo is 2·2 lbs.). [We presume that coagulated albumen was employed. We have not been able to see Mosso's reports of Schiff's researches published in *La Nazione*, 1872, Nos. 102, 109, 110, 116, S. A. 12mo. p. 59.]——Manasseïn, "Chemical contributions to our knowledge of Fever" (*Virchow's Archives*, LV. 1872, p. 413. Abstract in *Centralblatt*, 1872, No. 44) investigates digestion in (1) healthy dogs and cats, (2) dogs and cats rendered anæmic by depletion, (3) dogs and cats thrown into a febrile condition by the subcutaneous injection of putrid matter.——Möhlenfeld, "On the Peptones produced from Fibrin" (*Pflüger's Archives*, 1872, p. 381. Abstract in *Centralblatt*, 1872, No. 43).——Von Wittich, "Concerning Pepsin and its Action on Blood-fibrin" (*Pflüger's Archiv*, 1872, p. 435. Abstract in *Centralblatt*, 1872, No. 45).

LIVER.—Von Wittich, "On the Physiology of Human Bile" (*Plüger's Archives*, 1872, pp. 181), finds that fresh human bile obtained from a fistula contains, like the bile of other animals, a ferment capable of converting starch into sugar. The ferment may be isolated by precipitating the bile with alcohol and extracting the dried precipitate with glycerine. He also made the observation that if bile be filtered through animal charcoal, the bile acids are completely retained by the charcoal, and could not even be extracted from the charcoal by means of alcohol. In a more recent paper (*Ibid.* 1873, pp. 28) he shows that the ferment is really formed in the liver, and that it may be extracted from it after it has been washed for hours in a stream of water (see a fuller abstract of this last in *London Medical Record*, 1873).——"Oxidation Products of the Bile Pigments produced in Gmelins's Reaction," Stokvis (*Centralblatt*, 1872, No. 50), [a good paper].——"Determination of the Sulphur of the Bile," Külz (*Archiv für Anat. und Phys.* 1872, pp. 98. Abstract in *Centralblatt*, 1872, No. 56).——"Cholic Acid," Baumstark (*Berlin. Klinik. Wochensch.* 1873, No. 4. Abstract in *Centralblatt*, 1873, No. 16).——"Biliary Calculi." Ritter (*Journ. d. l'Anatomie*, 1872, No. 1. See Abstract in *Brit. and For. Med.-Chi. Review*, April, 1873).——"Action of Mercury on the Liver." Leading Article (*Brit. Med. Journ.* 1873, January 4th).

Pancreas.—[It is well known that, in the rabbit the pancreatic duct opens into the intestine twelve inches, or more, below the bile duct, and that Bernard observed the striking fact, that after the ingestion of food containing fatty substances, the absorption of the fat takes place after the food has passed the orifice of the pancreatic duct and not before this, although it has been subjected to the action of the bile. In other animals where the pancreatic duct opens with or near the bile duct, a short way below the pylorus, the absorption of fat begins much higher up than in the rabbit. Unabsorbed fat has been, in several cases of pancreatic disease observed in the fæces in the human subject. These and many other well-known facts have led to the prevailing belief that the pancreatic juice has to do with the digestion of fat, and indeed that if the flow of the juice into the intestine be prevented, the digestion of fat is incomplete. Bernard failed to preserve dogs alive after the extirpation of the pancreas ; so to prevent the secretion from entering the intestine, he injected melted tallow into the pancreatic ducts. In two cases the animals lived, and although they had voracious appetites, they became emaciated. The fæces contained undigested fat.]——Schiff (*Centralblatt*, 1872, No. 50. Abstract by Boll of Schiff's researches reported in *La Nazione*, by Dr A. Mosso) considers the non-absorption of fat in these dogs to have been probably due much more to the interference with the entrance of *bile* than of the *pancreatic juice* into the intestine. He thinks that the inflammation set up in the pancreatic ducts by the decomposing fatty matter may have led to partial or complete occlusion of the bile duct.. His reasons for thus thinking are derived from the following. He injected 16—27 Cm. of melted paraffin into the chief excretory duct (Hauptausführungsgang) of the pancreas of full-grown dogs. (He selected paraffin because it does not like tallow decompose and so tend to produce inflammation.) "In many cases the pancreas became swollen and tense throughout its whole extent. The autopsies performed after some time, showed the epithelium of the acini to be in a state of fatty degeneration or quite atrophied and gone, while the remainder of the gland preserved its form." In the most favourable cases the animals had good appetites, their weight increased during high feeding, and the fæces had a normal appearance. The digestion of fat was scarcely affected in any way. A normal dog can digest daily 12 grammes of fat for every kilogramme of body weight. Schiff found that on three successive days a dog on which he had operated took a larger quantity of fat than this, and in the excrements were found only "quite faint traces of fat." Then he has extirpated the pancreas in birds, and he finds that digestion appears to be scarcely at all disturbed. Colin and Bérard have done the same with like results. Although they always found that adult mammals die from the effects of such an operation, yet in newly-born mammals the gland may be extirpated, and notwithstanding this, the animals may live and grow. Schiff concludes from all this, that even in adult animals after elimination of the action of the pancreatic juice upon the food the other digestive fluids can carry on digestion perfectly. [It occurs to us to say, that although Schiff's statements regarding this matter obviously demand serious attention, nevertheless it is a pity (we judge from Boll's abstract) that in the dog experiments he should have blocked up only one of the pancreatic ducts with the paraffin. Why should we suppose that the lesser pancreatic duct did not continue to pour pancreatic fluid into the intestine, and why should we believe (in the absence of direct statement) that the portion of the gland in connection with this smaller duct was degenerated. On the contrary, its action may have become greater, and so may have secreted juice enough to digest the fat. If Schiff infers from these experiments that in Bernard's dogs the failure in the digestion of the fat was owing to the interference with the flow of *bile* into the intestine, it seems to us a very gratuitous assumption. Why may it not have been owing to inflammatory occlusion of the *smaller pancreatic duct?* We have not been able to procure *La Nazione.*]——*Brunner's Glands.* Krolow (Inaug. Dissertation. Berlin, 1872. Abstract in *London Medical Record,* 1873, No. 10).

Lymph.

H. Nasse ("Researches on the Influences which govern the Formation of Lymph," Marburg, 1871. Abstract in *Centralblatt,* 1873, No. 10), collected and measured the lymph obtained from the cervical lymphatics under various conditions. He found that ligature of the carotids diminished the lymph-stream to the extent of 24 to 40 per cent. After removal of the ligatures from the arteries the original quantities were seldom reached. With the diminution of the lymph there was a relative increase in the amount of its watery constituent. Compression of the external jugular veins increased the lymph-stream to the extent of 10 to 31 per cent. Experiments on the effect of venous depletion yielded the unexpected result that after depletion, either to *a large* or to a *small extent,* the lymph stream increased to from 10 to 31 per cent. [one would have anticipated the contrary]. A diminution first set in, in such cases when the coagulability of the lymph increased. The amount of water in the lymph after venous depletion, remained, contrary to expectation, in most cases unchanged; on the other hand, the amount of fibrin was diminished, and the amount of Na Cl was but slightly lessened. Researches on the influence of section and stimulation of the cervical sympathetic were not carried out to the entire satisfaction of the investigator, because of the difficulty of separating it from the vagus in the dog. In most of the experiments stimulation of the cervical sympathetic produced a great diminution of the lymph stream, in others the lymph stream was accelerated during the period of stimulation. Still less decided were the results of section of the sympathetic. Stimulation of the undivided vagus always increased the lymph stream. Stimulation of the central end of the divided nerve was followed by a considerable increase, while stimulation of the peripheral end of the divided nerve caused slight diminution. Stimulation of sensory nerves (which?) considerably increased the lymph stream. This he attributes to reflex contraction of vessels. The injection of 1 per cent. solution of Na Cl into the blood-vessels [how much?] enormously increased the lymph stream and diminished the coagulability of the lymph. Injection of water had—on the other hand—comparatively little effect. Carbonates of the alkalies increased the lymph stream, but little alkali, however, passed from the blood into the lymph. He also made researches with defibrinated blood, and found that this had no influence on the amount of fibrin in the lymph, but increased the solids of the lymph generally. He concludes from his researches that the lymph is a simple transudation. [On this explanation how is the effect of depletion to be accounted for?]

Milk.

Soxlet, "Contributions to the Physiological Chemistry of Milk" (*Centralblatt*, 1872, No. 53. Abstract in *Journ. of Chemical Soc.* Feb. 1873). Boussingault. (See *Journ. of Chem. Soc.* Dec. 1872.)

Schwalbe (*Schultze's Archives*, VIII. p. 269) says in opposition to Kehrer that milk globules have a membrane. If the oil be removed and the vesicles then be subjected to the action of osmic acid, the membrane exhibits a double contour. [It is surprising how anyone can doubt the existence of a membrane. The manner in which the globules run together and form masses of irregular shape after they have soaked for some time in acetic acid—under the microscope—appears to be only explicable on the view that there is a membrane which acetic acid is capable of dissolving.]

Urine.

Fr. Hofmann, "On the Passage of Free Acids through the Alkaline Blood into the Urine" (*Zeitsch. für Biologie*, VII. 3. Abstract in *Centralblatt*, 1872, No. 38). See also on the same subject Gaethgens (*Centralblatt*, 1872, No. 53). Soborow, "On the Excretion of Lime in the Urine" (*Centralblatt*, No. 39).——Falck, on the effect upon the urine of the injection of water into the blood ("Contribution to the Physiology of Water;" abstract in *Centralblatt*, 1873, No. 12).——Rabuteau, "On the Physiological effects and the Elimination of Urea introduced into the organism" (*L'Union Médicale*, 1872, No. 142, abstract in *Centralblatt*, 1873, No. 8).——Salkowski, "On the Estimation of Urea and Alkaline Chlorides in Urine containing Potassium Iodide" (*Pflüger's Arch.* 1872, V. Abstract in *Centralblatt*, 1873, No. 4).——Yvon, "On a New Method of determining Urea" (*L'Union Médicale*, 1873, January 11. Abstract in *Lond. Med. Record*, 1873, No. 13). Schultzen and Nencki, "The Antecedents of Urea in the Animal Organism" (*Zeitsch. für Biologie*, 1872, VII. p. 124. Abstract in *Centralblatt*, 1872, No. 50).——Salkowski, "Estimation of Potassium in the Urine" (*Pflüger's Arch.* 1872, VI. Abstract in *Centralblatt*, 1873, No. 2).——Maley, "Estimation of Uric Acid" (*Pflüger's Archives*, 1872, VI. p. 201. Abstract in *Centralblatt*, 1872, No. 48).——Pawlinoff, "On the Sources of the Uric Acid in the Organism" (*Centralblatt*, 1873, No. 16).

DECOMPOSITION OF URIC ACID, by Bacteria.—R. Lex (*Centralblatt*, 1872, No. 33) finds that if a solution of Sodium Phosphate and Uric Acid be kept at a temperature of 20 to 30° c., with a moderate supply of air, Bacteria develope within a few days. When they make their appearance the previously acid reaction of the fluid begins to decline, and in the course of from eight to fourteen days from the commencement of the experiment the acid reaction completely disappears, and alkalinity takes its place. Then, the muroxide test fails to detect the slightest trace of Uric Acid, but on the other hand the presence of Urea and Ammonium Carbonate may be readily ascertained by the usual methods. This decomposition of Uric Acid into Urea and Ammonium Carbonate is ascribed by Lex to the fermentative action of the Bacteria. He supposes that Oxygen and Water are taken up during the decomposition.

SOURCE OF URINE PIGMENT.—R. Maly (*Annal. der Chem. und Pharm.* Vol. 163, p. 77) communicates further information regarding his statement (*Journ. of Anat. and Phys.* Vol. VI. p. 468), that when Bilirubin suspended in water is treated with a strong reducing agent, such as Sodium Amalgam for 2 to 4 days, a substance is produced which is identical with Jaffe's urine pigment Urobilin. This substance Maly names Hydrobilirubin, because it contains more water than Bilirubin. Its composition is $C_{32}\ H_{40}\ N_4\ O_7$. It is a feeble acid, readily soluble in alkaline solutions, from which it may be precipitated by the addition of acids. It is sparingly soluble in water, but dissolves readily if the water contain Sodium Phosphate. Its colour changes under the action of acids and alkalies: its spectral characters, etc. all show its identity with Jaffe's Urobilin. Maly found Hydrobilirubin abundantly in the pigment separated from the urine after Scherer's method. He asserts that in the intestine—especially the large intestine—Hydrobilirubin is formed from the colouring matter of the bile, that it is absorbed from the intestine and is excreted by the kidneys. This absorption is not complete however, for Hydrobilirubin occurs in the fæces. From the spectrum, Maly ascertained the existence of traces of Hydrobilirubin in the serum of the blood of the ox, and he ascertained that if this pigment be injected subcutaneously it is speedily absorbed and excreted in the urine. Masius and Vanlair supposed (*Journ. of Anat. and Phys.* Vol. VI. p. 468) that the substance named by them Stercobilin differs but little from Hydrobilirubin. According to Maly this substance of theirs has no existence. Lastly he cannot agree with Heynsius and Campbell in thinking that Urobilin is identical with the final product of the oxidation of Bilirubin—to wit, Choletilin; for this, unlike Urobilin, shows no fluorescence, and moreover it differs in other essential particulars. Stokvis, "Identity of Choletilin and Urobilin" (*Centralblatt*, 1873, No 14).

Lachrymation.

Demtschenko (*Pflüger's Archives*, 1872), from experiments on dogs, cats and rabbits, narcotised by morphia, finds that electrical stimulation of the cervical sympathetic causes an increase of the lachrymal secretion; it moreover increases the secretion from the conjunctiva, even after removal of the lachrymal gland. Electrical excitement of the lachrymal nerve increased the secretion. The sympathetic tears were cloudy—the lachrymal nerve tears were clear and watery [analogous to the sympathetic and chorda saliva]. The increased lachrymal secretion which follows stimulation of the frontal infraorbital, nasal, lingual, glossopharyngeal and vagus nerves stops if the lachrymal nerve be divided, but section of the sympathetic has no effect. Nevertheless in cases of palsy of the fifth nerve, the conjunctiva remains moist although the person cannot shed tears.

Skin.

Aubert, "On the amount of CO_2 excreted by the human skin" (*Pflüger's Archives,* 1872, VI. p. 549. Abstract in *London Med. Rec.* 1873, No. 4).

Bone.

Ollier, "On the Growth of Bone" (*Archives de Physiologie*, 1873. Abstract in *London Med. Rec.* 1873, No. 5).——Philipeaux, "On the Formation of Bone from Periosteum" (*London Med. Rec.* 1873, No. 6).——Weiske-Proskau, "Effect on the Composition of Bone of different Earthy Phosphates in the Food. (Abstract in *Centralblatt*, 1872, No. 57).——Aeby, "Composition of Bone Phosphates (*Centralblatt*, 1873, No. 7).

Muscle.

Schenk, "On the Amount of Nitrogen in Flesh" (Abstract in *Centralblatt*, 1872, No. 45).—Salkowski, "On the Composition of Muscular Substance of the Heart" (*Pflüger's Arch.* 1872, p. 213. Abstract in *Centralblatt*, 1872, No. 56).——Marcet, "On the Nutrition of Muscle and Lung in Health and in Phthisis" (*Philosoph. Mag.* Nov. 1872. Abstract in *London Med. Rec.* 1873, No. 7).——Fick, "On the Measurement of Muscular Power." See abstract (in *London Med. Rec.* 1873, No. 6).——Preyer, "Myophysical Researches" (*Pflüger's Arch.* VI. p. 237).——A Criticism of these, by J. Bernstein (*Ibid.* VII. p. 90).——Volkmann, "Relations of Elasticity to Muscular Activity" (*Pflüger's Arch.* Jan. 1873).

Animal Heat.

Siemens, "On measuring Temperatures by Electricity" (*Nature*, 1872, May 16).——Casey, "Diurnal Variations of the Temperature" (*Lancet*, 1873, Feb. 8).——Senator, "Researches on the Production of Heat and Tissue Metamorphosis" (*Reichert und Reymond's Archiv* 1872, p. 1. Abstract in *Centralblatt*, 1872, No. 42).——J. Rosenthal, "Regulation of Temperature in Warm-blooded Animals" (*Erlangen*, 1872. Abstract in *Centralblatt*, 1872, No. 53), among other things states the important fact that he—like Riegel (see *Academy* for Sept. 1, 1872) has been unable to confirm Nauyn and Quincke's statement, that section of the spinal cord is followed by an increased production of heat in the paralysed parts. [On this has been founded the rash conclusion that there are nerves which inhibit the production of heat, and owing to section of these nerves in the spinal cord, an increase in the amount of heat is the result.] Section of the spinal cord is, as one would expect, followed by increased *loss* of heat owing to dilatation of blood-vessels. When the temperature of the surrounded medium is raised, the temperature of animals thus injured does not rise faster than in normal cases. Some considerable time after the operation there is indeed an increase in the temperature of the animal, but this is apparently owing to a febrile condition resulting from the wound. ——Winternitz, "Regulation of Temperature" (*Virchow's Arch.* 1872, LVI. p. 181. *Centralblatt*, 1873, No. 12).——Horvath, "On the Physiology of Animal Heat" (*Centralblatt*, 1872, Nos. 45, 46, 47. Abstract of No. 45 in *Journal of Anat. and Phys.* Nov. 1872, p. 185). ——"On the Behaviour of Frogs under the Influence of Cold" (*Centralblatt*, 1873, No. 3).——Stricker and Albert, "On the Temperature of the Heart" (see abstract in *London Med. Record*, 1873, No. 8), find the blood in the right warmer than that in the left ventricle, and that this difference is not due, as Heidenhain and Körner supposed, to the proximity of the right ventricle to the liver. They found that when the abdominal cavity was opened and the liver separated from the under surface of the diaphragm, that the blood in the right ventricle still remained warmer than that of the left ventricle. See also ——Bernard, "Lectures on Animal Heat" (*Revue Scientifique*, 1872).

Generation.

"Theory of evolution in Germany" (*Nature*, 1873, March 6 and April 3).

BEGINNINGS OF LIFE.—Dr Burdon Sanderson (*Nature*, Jan. 9, 1873) gives an account of experiments on the origin of Bacteria performed by Dr Bastian and himself. The experiments show that Dr Bastian was right in stating that Bacteria appear in turnip infusion containing cheese, although it be kept in sealed glass flasks after the infusion has been boiled in the flask for as much as ten minutes. See leading article (in *Brit. Med. Journal*, Feb. 1, 1873, and *London Med. Record*, 1873, No. 10).——Bastian, "On the Temperature at which Bacteria, vibriones, and their supposed germs are killed, when immersed in fluids or exposed to Heat in the moist state" (*Nature*, March 27 and April 3, 1873).——Roberts, "Criticism of Bastian's Experiments" (*Nature*, Feb. 20, 1873).——Huizinga, "New Experiments on Abiogenesis" (*Nature*, March 20, 1873).

Miscellanea.

Bert, "Influence of Barometric Pressure on the Phenomena of Life" (Abstracts in *London Med. Rec.* 1873, Nos. 10 and 13.——Liborius, "On the Quantitative Estimation of Albumen" (Abstract in

Centralblatt, 1872, No. 55).——Salkowski, "Reaction of Cholesterine with Sulphuric Acid" (*Pflüger's Arch.* 1872, VI. Abstract in *Centralblatt*, 1872, No. 55).——Hüfner, "Amorphous Ferments" (*Journ. für practische Chemie*, V. p. 372. Abstract in *Centralblatt*, 1872, No. 37).——Böhm, "Influence of Arsenic on the Action of Amorphous Ferments" (Abstract in *Centralblatt*, 1873, No. 6).——Vulpian, "On the Septic Virus" (see *London Med. Rec.* 1873, No. 9).——Davaine, "On the same subject" (*Ibid.* No. 8).——Rabuteau and Papillon, "Physiological and Anti-fermentative action of Sodium Silicate" (*Comptes Rendus*, 1872, LXXV. p. 755. *Centralblatt*, 1872, No. 54).——"Article on Flowers and Fevers" (*Brit. Med. Journal*, 1873, March 29).

THE VARIETIES IN THE MUSCLES OF MAN. The abstract of three Lectures delivered by Professor HUMPHRY at the Royal College of Surgeons of England on June 2nd, 4th and 6th, 1873[1].

LECTURE I.

IN the three lectures on Myology which Professor Humphry delivered last year at the College of Surgeons[2], he showed that the several muscles in man are modifications of the simple pattern which is found in certain lower animals. In the present course of Lectures he proposed to show that the varieties in the muscles are to be viewed in the same light and that they are, generally, the result of an imperfection in those processes of segmentation from the simple type and of concentration, by which the more complete specialization of the several parts of the muscular system in man is attained. These varieties, as well as the modifications of which they are varieties, have a relation to utility in this way: taking the normal standard of muscular disposition, as the most perfect and therefore the most constant, those variations from it are the most frequent which least interfere with the movements of the body. Those muscles, that is to say, are the most frequently wanting and, on the whole, the most liable to variety which can be best spared and the variations in which are least detrimental, such as the pyramidalis abdominis, the palmaris longus and the psoas parvus.

The principle of subdivision or segmentation of muscles for the purpose of varied action, and that of concentration upon particular points for the purpose of definiteness of action, is carried to its greatest extent in man, particularly in the limbs, and especially in the upper limb; and it is in these parts that varieties most frequently occur. The want of proper segmentation is also most frequent in the case of muscles which lie parallel and have similar action, as the radial extensors of the wrist, which are often united; whereas the peroneus longus and

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[1] These Lectures will be published at length in the *British Medical Journal* during this and the ensuing month.

[2] Published in the *British Medical Journal* of June and July, 1872.

peroneus brevis which pass to different parts, and which, though parallel in great part of their extent, have different actions, are rarely found to be preternaturally blended with one another.

The imperfection in concentration was illustrated by the extension of the coraco-brachialis upon the humerus, as in the case of many lower animals, also by the presence of supernumerary muscles, as in the case of a cleido-occipitalis or an additional coraco-brachialis; such muscles being usually adjuncts to, or reduplications of, ordinary muscles.

With regard to the correlation of varieties, the lecturer observed that several are often present in the same subject, and they are often associated with varieties in other structures; and the same kind of variety is often repeated in the same person. They are also often symmetrical; but the corresponding varieties are not commonly found in the upper and the lower limbs, that is, the serially homologous muscles are not usually affected in the same person.

Males and females, and also the two sides of the body, are equally liable to be affected; and the other races of mankind and some of the lower animals are, as far as the evidence goes, as liable to muscular varieties as ourselves.

The varieties are themselves very varied, that is, an additional muscle or head of a muscle is scarcely alike in any two instances of its occurrence. There are however certain lines or directions, as they have been called; and these are often in the direction of the normal form of some lower animal and chiefly of those nearest to man, but also, not unfrequently, of those remote from him in the animal scale. This the lecturer regarded as an illustration of the similarity of the forces which are in operation in the evolution of the several animals, and not necessarily as an evidence that the one animal has been evolved from the others, and that the varieties are therefore to be regarded in the light of reversions to the form of some other animal or animals.

The muscles of the abdomen were first considered. The varieties in most of these were described as few and infrequent, which accords with the simple disposition of these muscles and the little variation they present in the different classes of animals. In the obliqui and transversalis they are almost limited to the occasional persistence of inscriptions over the ribs or the costal cartilages. The most frequent varieties are in the two muscles which are most easily spared, viz. the pyramidalis and the psoas parvus. These are often absent; yet one of them, the psoas parvus, is very generally present in Mammals, while the other is more frequently absent. In the rectus also the varieties are few. In the lower animals this muscle is often prolonged upon the thorax as far as the first rib. This is not the case, even as a variety, in man. Still muscles not continuous with the rectus, but in other respects resembling this continuation of the rectus, and forming what the lecturer called the 'rectus thoracicus profundus,' are sometimes found beneath the pectoral muscles. They are to be distinguished from the 'rectus thoracicus superficialis,' also called 'sternalis,' which lies upon the surface of the pectoralis, is often continuous with the sterno-mastoid, and which the lecturer believed to be, not as supposed by some, a part of the platysma series, but a partial representative of that extension of those superficial strata of the mesial portion of the abdominal wall into the sterno-mastoid which are found in some of the lower vertebrates. It was pointed out that this last-named anomalous muscle—the rectus thoracicus superficialis—has no representative in other Mammals, or in Birds or higher Reptiles; and it was suggested that its frequent occurrence in Man may have some relation to the flatness of the front of his thorax, affording space for its development.

The muscles of the neck were next discussed. The platysma and the sterno-cleido-mastoid do not often present varieties; though the former is sometimes developed upon the trapezius or over the parotid gland, or furnishes slips to the deeper muscles, and the latter is sometimes imperfectly separated from the trapezius. The varieties in the digastric and stylo-hyoid, which are numerous and frequent, were given at some length and were shown to be confirmatory of the views elsewhere[1] expressed by the Professor, that the anterior belly of the digastric is derived from a superficial cervical stratum, and the posterior belly and the stylo-hyoid from a deeper stratum, and that the intermediate

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[1] This *Journal*, VI. 324, and *Observations in Myology*, by Professor Humphry, p. 136.

tendon is the remnant of the hyoidean intermuscular septum. The occasional presence of an inscription in the sterno-hyoid and sterno-thyroid was noted as a remnant of one of the primitive transverse intermuscular septa; some other irregularities in these muscles were noted.

LECTURE II. Delivered June 4, 1873.

The muscles connecting the upper limb with the trunk—the superior ventro-appendicular muscles—were described as in two sheets; a superficial and a deep sheet.

The superficial sheet which, in some of the lower animals, as Lepidosiren, forms an almost continuous funnel-like expansion from the trunk upon the limb, without defined divisions or boundaries, is, in Man, divided into three segments or sectors—the pectoralis, the latissimus dorsi and the trapezio-deltoid. These have tolerably definite boundaries at either end; though the segmentation from surrounding muscles is still not quite complete. Thus, the pectoral muscle usually presents evidence of imperfect separation from the external oblique in the form of connecting slips; and the latissimus dorsi is commonly connected with the triceps. The varieties in the components of this sheet are, for the most part, due to a still less complete separation of them from one another, or from the contiguous muscles, at their proximal or their distal ends. The bands so often found more or less bridging over the axilla and passing from the latissimus dorsi or the pectoralis, or the ribs contiguous to them, to one or other of those muscles or to the humerus or the coracoid, and constituting the various 'axillary muscles' or 'achselbogen' are of this nature; also the blendings of the pectoral with the deltoid, and of the latter with the trapezius. The costo-epitrochlien was described as a segmented extension of the pectoralis. Various muscles described as cervico-humeral, cervico-clavicular, masto-scapular, occipito-scapular, &c., were shown to stand in a similar relation to the trapezius, and to form, with the rhomboids, fragments of a deeper layer of the trapezius. The varieties in the deeper layer of the pectoralis, which forms the pectoralis minor, are frequent, and consist chiefly of extensions of the muscle, over the coracoid, to the humerus, the capsule of the shoulder, the supra-spinatus tendon, &c., simulating the disposition of the pectoralis minor in many of the lower animals and of the levator humeri in birds. The imperfection of concentration or limitation, distally, is shown by the extension of the latissimus dorsi and of the pectoralis down the arm, where they blend with the several muscles and more particularly with the triceps; and the deltoid is sometimes prolonged to the supinator longus, as in Manis and Birds.

The deeper layer of the ventro-appendicular sheet consists of the subclavius, the omo-hyoid, the levator-scapulæ, and the serratus magnus. Of these the subclavius is sometimes prolonged in both directions, forming the sterno- or costo-scapularis. The omo-hyoid presents many varieties of imperfect concentration, being often extended upon the clavicle and sometimes being unsegmented from the sterno-thyroid; or it may spread upon the upper edge of the scapula as far as the levator scapulæ; and one or both bellies may be double or variously disposed. The levator scapulæ and the serratus may present the want of separation so common in lower animals; or they may be over segmented, either being in two or more parts; and they may extend at their origin or insertion beyond the usual area.

The varieties in the deep muscles of the shoulder are few and unimportant.

The adducto-flexor muscles—coraco-brachialis, biceps and brachialis anticus—offer many examples of imperfect separation and concentration. The two former retain a union at and near the coracoid in the normal state; and all three are liable to be variously blended and extended. The coraco-brachial is sometimes spread upon the inner side of the humerus, more or less approaching to its disposition in Monotremes and Reptiles. The biceps has often two or more origins from the humerus, and below is often connected with some of the muscles of the forearm. It rarely acquires a partial insertion into the ulna, though this is often the case in lower animals, its action as a supinator of the forearm in Man requiring its limitation to the radius. The brachialis anticus is sometimes imperfectly segmented, above, from the coraco-brachialis and the biceps, and, below, from the muscles of the forearm. The triceps presents few irregularities.

In the forearm the palmaris longus varies often and in every conceivable way. The other pronato-flexor muscles present many examples of deficiency of separation. In the normal state most of them retain some of the union which in the primitive form is more extensive; and the irregularities present many conditions of union intermediate between the normal and the primitive form. The internal condyle of the humerus and the coronoid process of the ulna were pointed out as the two chief meeting points or starting points of these muscles, especially the coronoid process; and many of the irregularities consist of unusual, or unusually extended, connections with this process. The flexor longus pollicis, which is more segmented from other muscles in Man than in the lower animals, still in him retains its hold upon this process, and often fails to be separate from the flexor digitorum. The numerous irregularities in the flexors of the fingers were alluded to in connection with the varied disposition of these muscles in lower animals. The flexor sublimis and the flexor profundus are, together with the flexor longus pollicis, divisions of one muscle, and the retention of the union is often presented by slips passing between them and by union of their tendons, and especially of those going to the little finger. The lumbricales, though usually remaining with the flexor profundus alone, sometimes are connected with the flexor sublimis, or with the flexor longus pollicis; or they may extend up to the coronoid process. The flexor carpi radialis sometimes extends, above, upon the coronoid process, and is blended with the other muscles; and, below, it may range upon the carpal bones, and upon the third and fourth metacarpals. A flexor carpi radialis brevis, passing from the radius to the carpal bones or the metacarpals, has in several instances been met with, and is a reminder of the extensive attachment of the pronato-flexor mass to the bones of the forearm and to the carpus and the metacarpus in the Cryptobranch and other Urodelans.

On the dorsal aspect of the forearm, the supinators and the radial extensors of the wrist are often incompletely separated from one another and from the adjacent muscles. The extensor digitorum is often not separated from the extensor carpi ulnaris; and the extensor minimi digiti is an incomplete segment from between them, which often ranges upon other fingers besides the fifth. In the deeper layer, the extensors of the thumb, which in Man only are devoted each to its particular bone of the thumb, often fail to attain this individuality in him. They are frequently blended. Especially is this so with the extensor primi internodii, which has less expressed function than the others and is often absent. In like manner the extensor indicis is frequently not separate; or it ranges upon other fingers; or it is absent.

LECTURE III. Delivered June 6.

In the lower limb the muscular irregularities are fewer than in the upper limb, owing, partly, to the less complex disposition of muscles in the limb and to the absence, in consequence of the fixity of the pelvic girdle, of muscles, the homologues of which, in the upper limb, are the seat of many varieties. The sartorius is the most erratic of those passing from the pelvis, and it is the most variable in lower animals. The biceps, by its occasional connections with the gluteus and extension to the sacrum and the crista of the ilium, harks back, as it were, to its primitive relations with these parts[1]. The adductors may be variously segmented. The semitendinosus, semimembranosus and popliteus do not vary much.

The irregularities in the calf-muscle are on the side of excess rather than of deficiency; although that muscle is in Man more complicated than in any other animal. They consist chiefly in the presence of additional heads to the gastrocnemius, or in extensions of the origin of that muscle and of the soleus. The plantaris is sometimes absent or abnormally connected with adjacent parts above or below.

In the deep flexor muscles the most interesting varieties are in connection with the accessorius, which is a remnant of the primitive wide attachment of the simple unsegmented flexor mass in the Urodelans to the bones of the leg, the tarsus and the metatarsus. Accordingly extensions of it, or derivatives from or adjuncts to it, are often found spreading up the leg

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[1] See *British Medical Journal*, *July* 20, 1872, *Journal of Anatomy*, VI. 355, *Observations in Myology*, p. 167.

along the fibula or widely connected with the tarsus. Below, it is sometimes more largely united with the flexor digitorum than usual, or it joins the flexor hallucis or the lumbricales, or it gives off one of the flexor tendons of the toes. The varieties in the flexors of the toes consist chiefly in the closer union of the flexor digitorum and the flexor hallucis, as is the case in lower animals, and in the partial absence of the flexor brevis, or the blending of it with the flexor longus, which more particularly happens with regard to the division to the little toe.

On the dorsal aspect of the limb the quadriceps is but little liable to varieties. The portion of the tibialis anticus attached to the metatarsal bone is sometimes separate; and, further, is sometimes subdivided, one portion passing to the first phalanx, thus resembling the disposition of the extensor tendons to the pollex. Sometimes the tibialis anticus extends to the plantar fascia; or it ranges upon the dorsum of the foot, as in the Hippopotamus. The peroneus longus seldom varies; though sometimes attached to other metatarsals, in addition to the first, it rarely or never fails to reach the first. The other peronei often show their imperfect segmentation from the extensor digitorum by spreading upon the toes. Particularly is this the case with the peroneus tertius, the complete separation of which and its devotion exclusively to the tarsus is a human feature, and is related to the mode in which the fore part of the sole is planted fully upon the ground in Man.—The extensor digitorum sometimes shows a persistence of connection with the metatarsal bones with the extensor hallucis and with the extensor brevis, which are reminders of the primitive oneness of the extensor mass, and which are evidences of imperfect segmentation of it. No instance had presented itself however of that extension to the fore part of the femur which is so frequent in other Mammals.—The varieties in the small muscles of the foot and hand were also discussed.

In indicating the relation between utility and variability, and showing that that which is most useful has on the whole the greatest stability, the Professor did not express any view as to the connection between the two, or wish to prejudge the great questions associated with this subject and with the allied problem how that which is most fitted for its purpose in each animal and each part comes to be present. Other questions were alluded to. Whether, for instance, the variety in muscles which are of least importance, on the one hand, and in those which are peculiar to Man, on the other, is an indication that those muscles are in process of being fixed in, or expunged from, the economy. Also whether varieties are more or less frequent in the more advanced and more civilized members of the human family than in others. At present there is not sufficient evidence to furnish an affirmative answer to any of these questions, or to establish the hereditary transmission of muscular varieties, which must be regarded as probable.—The nerve-supply to the supernumerary muscles, in the few instances in which it has been described, seems to corroborate the view "that nerve-course is somewhat too arbitrary or too much regulated by convenience in each instance for us to be able to rely upon the disposition of the nerves as sure guides to the discernment, in difficult cases, of the homological relations of muscles and other structures[1]."

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[1] *Journal of Anatomy*, VI. 56, *Observations in Myology*, p. 56.

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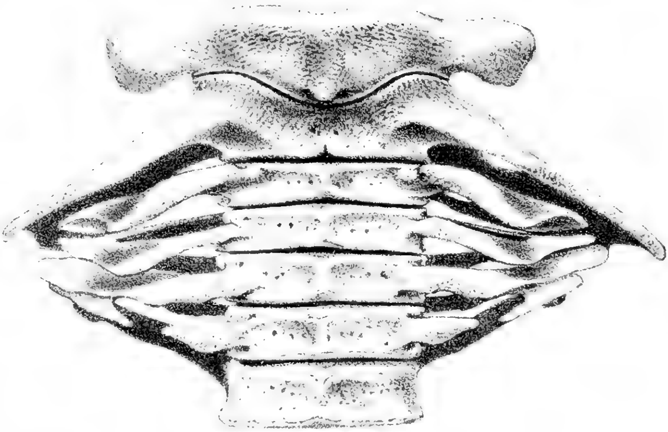

FIG. I

[illegible] Balaen[illegible] Peterhead, 18[illegible] Under aspect. $\frac{1}{12}$.

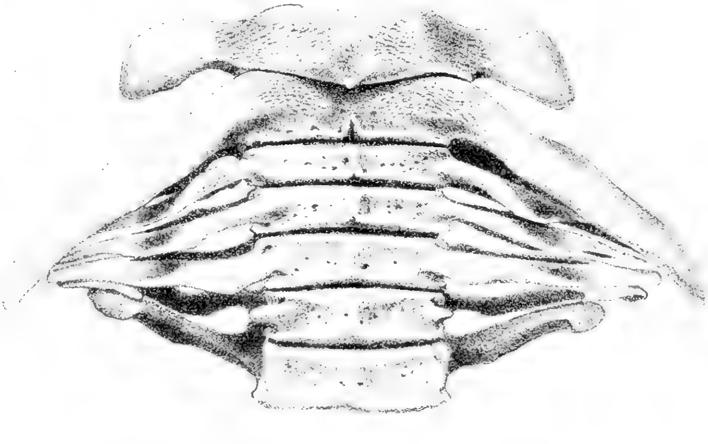

FIG. II

B. musculus. Stornoway 18[illegible] Under aspect. $\frac{1}{12}$.

CERVICAL [illegible]

Keith & Gibb Lith^rs Aberdeen

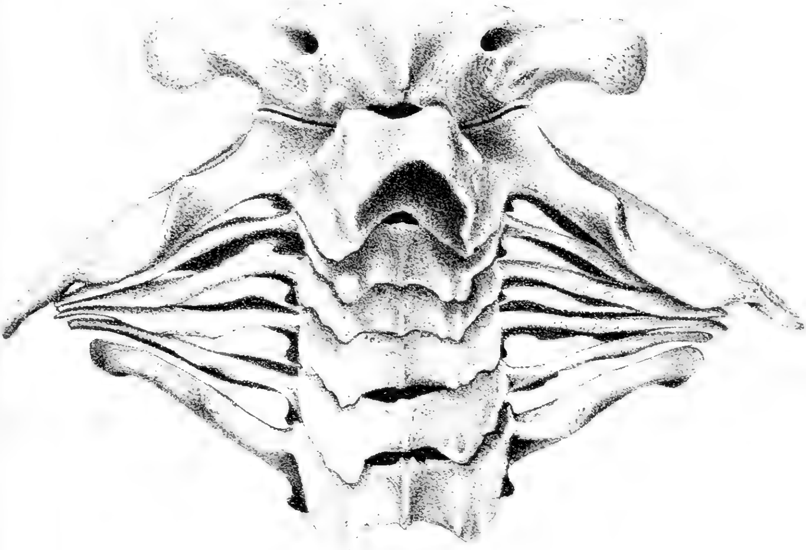

FIG. III

B musculus Wick 1869 upper aspect $\frac{1}{11}$

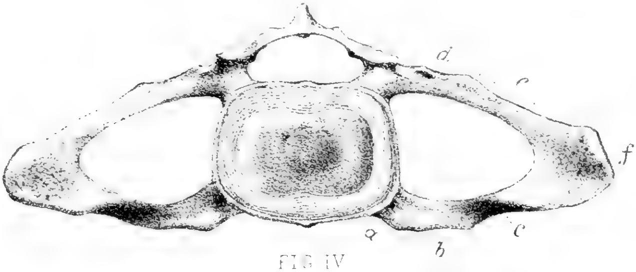

FIG. IV

Fifth cervical vertebra of B musculus (Stornoway Fig 2) Front aspect $\frac{1}{12}$

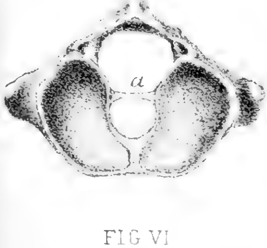

FIG VI

Atlas of young B. rostrata, with
Transverse ligament. Aberdeen.
1870. Front aspect. $\frac{1}{6}$

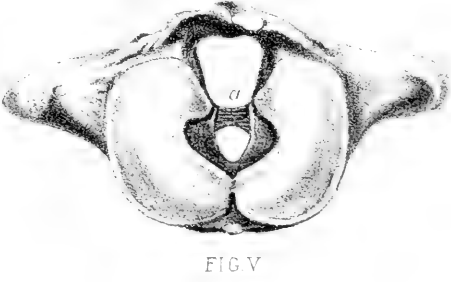

FIG. V

Atlas of B musculus with Transverse
ligament (Wick Fig. 3) Hinder aspect $\frac{1}{12}$

ARTICULATIONS IN FIN-WHALES.

Fig. 1.

2

3.

life size

4.

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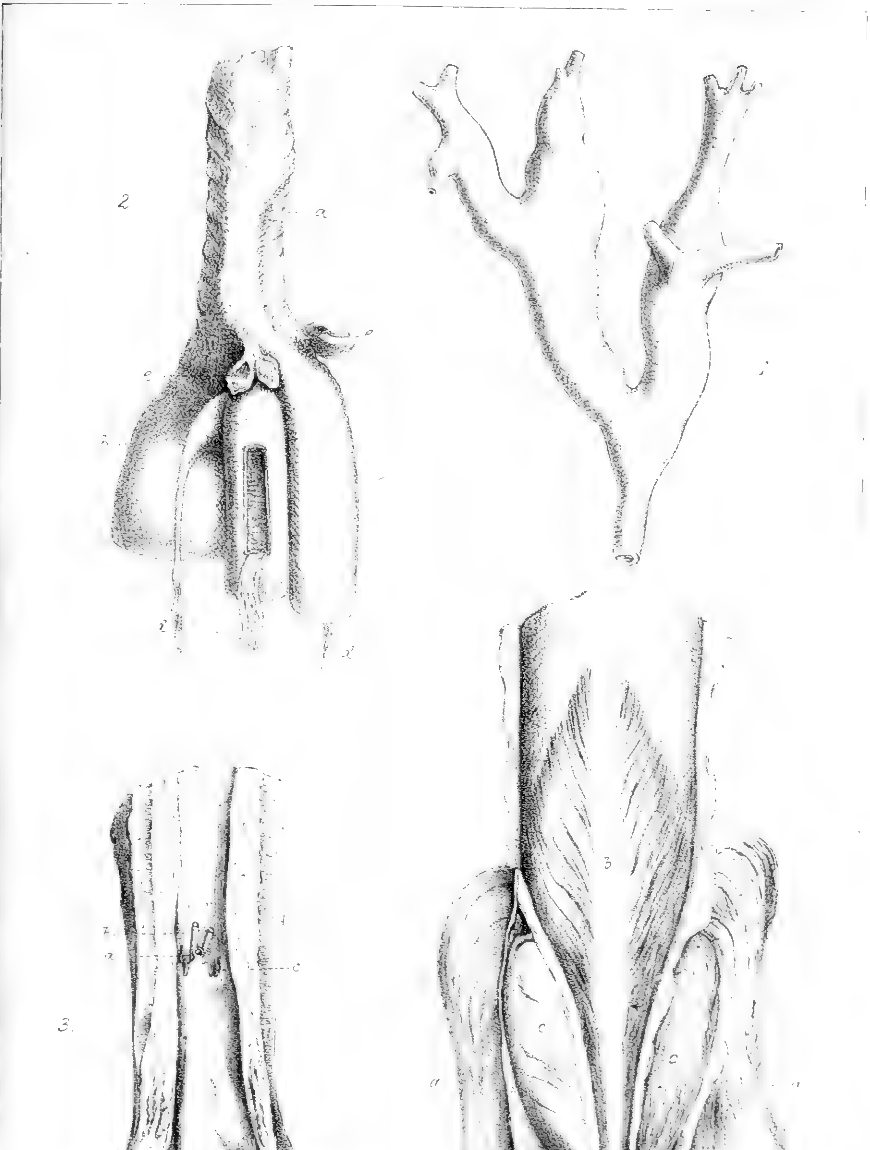
QUADRUPLE MAMMÆ IN A MAN.

Plate IV.



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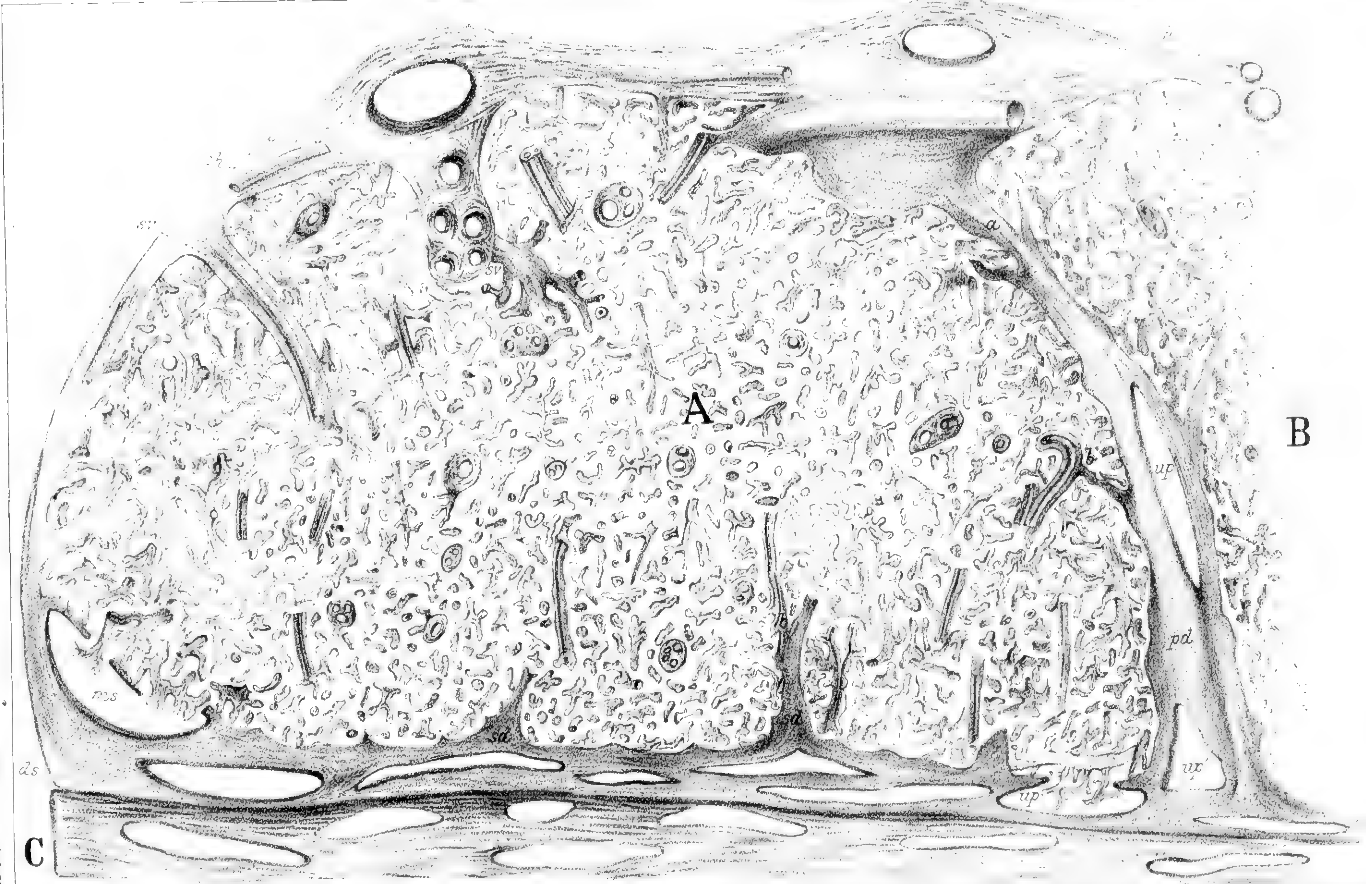
GENITO URINARY ORGANS OF ELEPHANT.



W. Turner, delt

HUMAN PLACENTA

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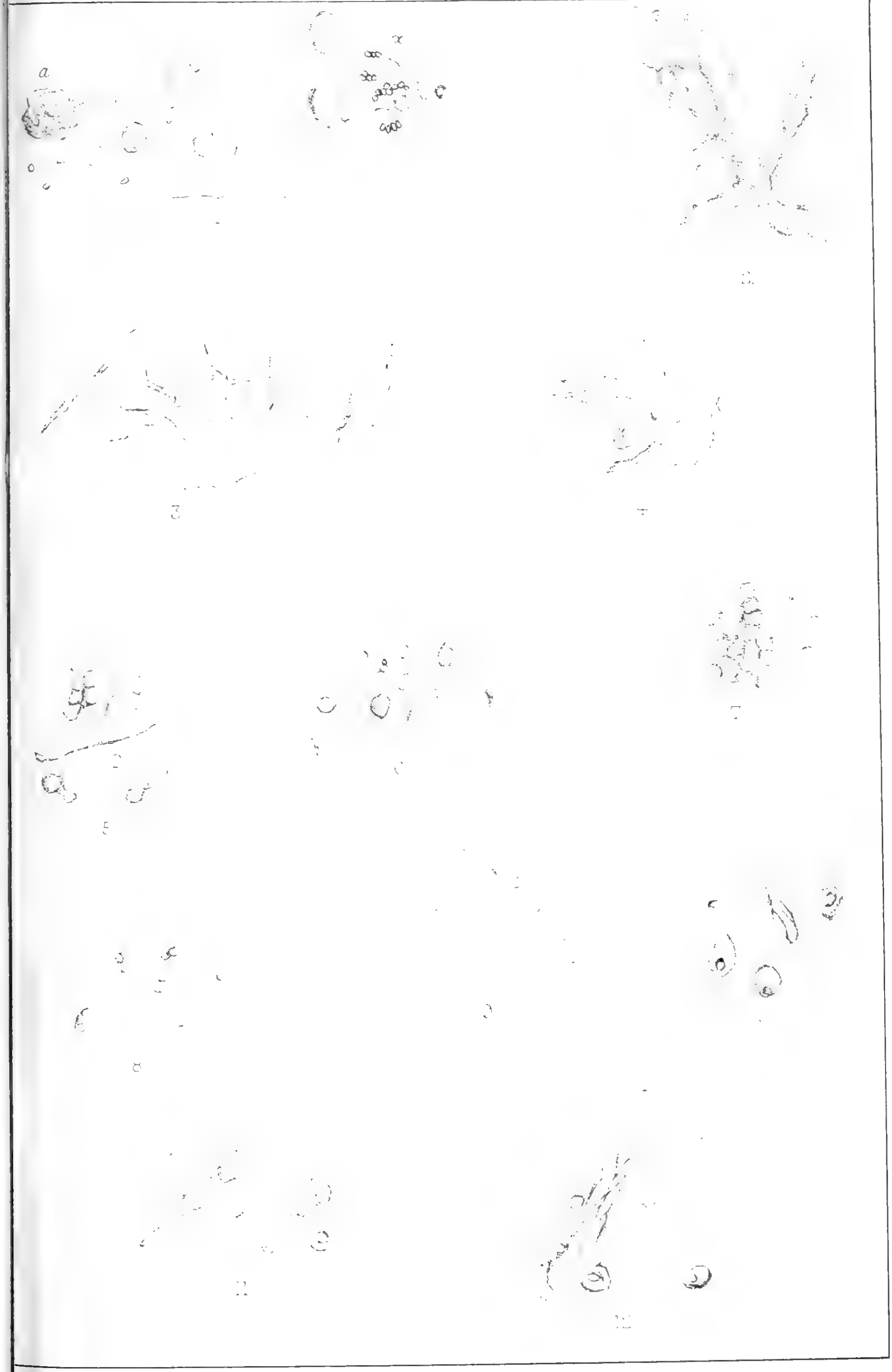
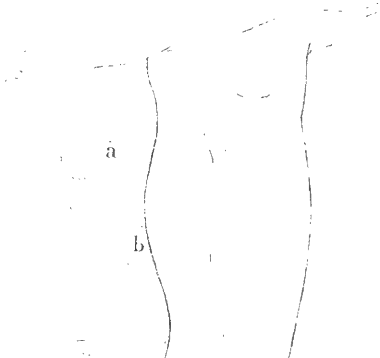


Tissue Metabolism. part 2. (p. 80)



Malformation of Leg and Foot (p. 156)

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