THE JOURNAL OF ANATOMY AND PHYSIOLOGY

CONDUCTED BY

G. M. HUMPHRY, M.D. F.R.S.
PROFESSOR OF ANATOMY IN THE UNIVERSITY OF CAMBRIDGE,
HONORARY FELLOW OF DOWNING COLLEGE;

AND

WM. TURNER, M.B.
PROFESSOR OF ANATOMY IN THE UNIVERSITY OF EDINBURGH.

VOLUME IX.

(*SECOND SERIES, VOL. VIII.*)

MACMILLAN AND CO.
Cambridge and London.
1875.

Cambridge:
PRINTED BY C. J. CLAY, M.A.
AT THE UNIVERSITY PRESS.

CONTENTS.

FIRST PART. NOVEMBER, 1874.

SECOND PART. MAY, 1875.

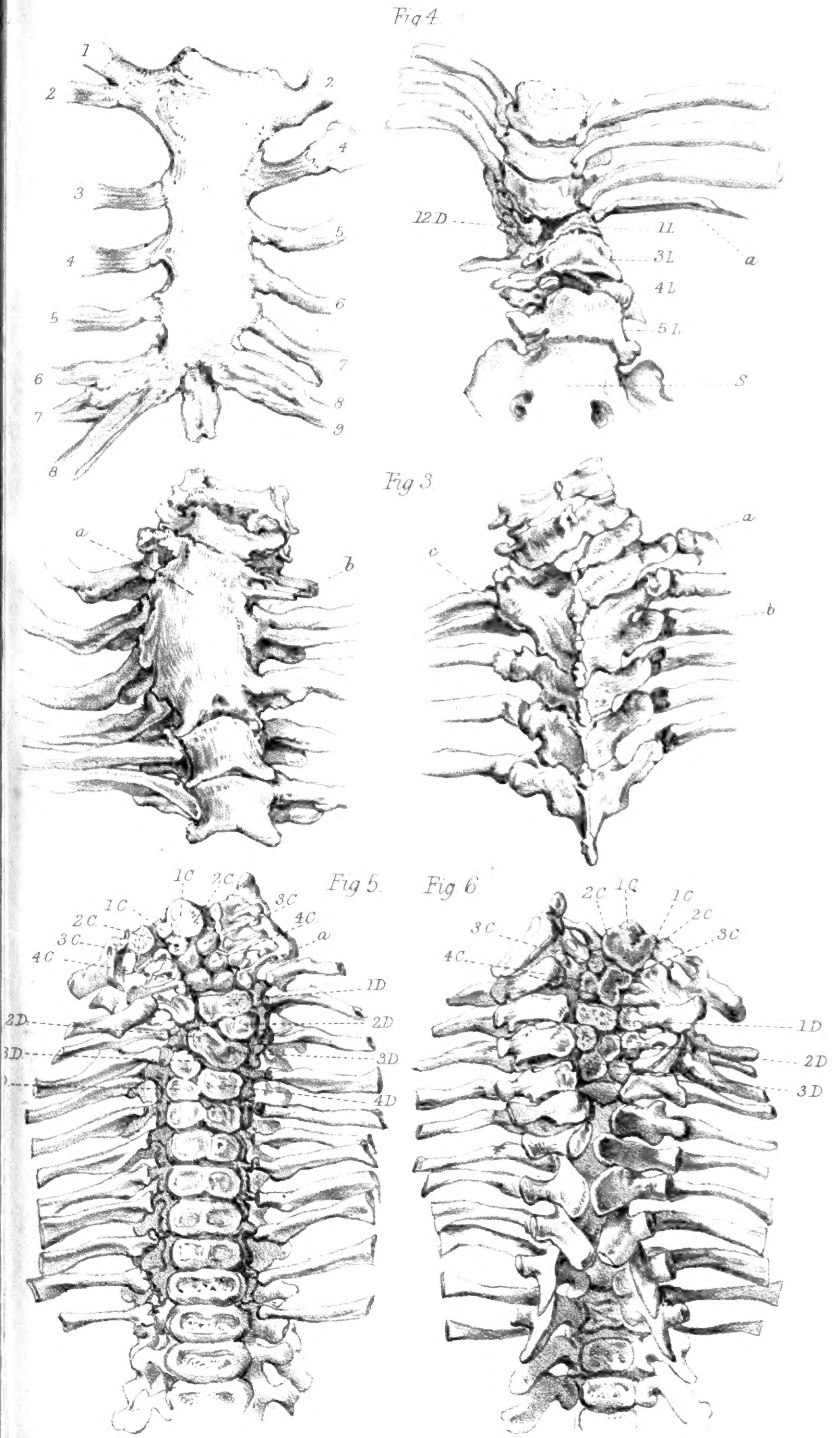


Fig 4
1
2
2
4
3
5
4
6
5
7
6
8
7
9
8
12 D
1 L
3 L
a
4 L
5 L
S
Fig 3
a
b
a
c
b
Fig 5.
Fig 6.
1 C
2 C
1 C
3 C
2 C
4 C
3 C
a
4 C
1 D
2 D
2 D
3 D
3 D
4 D
2 C
1 C
1 C
2 C
3 C
3 C
4 C
1 D
2 D
3 D

Journal of Anatomy and Physiology.

DESCRIPTION OF THREE CASES OF MALFORMATION OF THE SPINAL COLUMN ASSOCIATED WITH LATERAL CURVATURE. By JAMES F. GOODHART, M.D., *Demonstrator of Morbid Anatomy, and Medical Registrar at Guy's Hospital, Pathological Assistant in the Hunterian Museum.* (Pl. I.)

IT may perhaps be doubted how far good is likely to accrue from drawing inferences concerning normal development from the conditions found in monsters. Granting this to the full, the interest attaching to malformations does not subside. They will still have an individual noteworthiness, and they are always suggestive. From either aspect, whether as being departures from the normal and thus indicating some of the yet secret steps by which perfect development is accomplished, or as mere curiosities and freaks of nature, the cases I have now to record will not be thought out of place in a journal devoted to Anatomy and Physiology.

Case 1.—It is the skeleton of an adult male, 64 years of age, which has been recently added to the Hunterian Museum at the College of Surgeons. Of its previous history I could learn very little. It was ascertained, however, that the man was the offspring of a lamplighter and a ballad-singer, and even from early childhood had been known to be dragged about crippled, by his mother, as an additional stimulant to the flow of "Charity." For many years before his death he was the inmate of a workhouse, always enjoying good health, and never paralyzed. He died of some acute chest disease.

General appearance, &c.—Height $50\frac{1}{2}$ inches. The trunk is tilted so that the left elbow and hand come two inches lower than those on the right side. The left olecranon is about on a level with the lesser trochanter.

The extremities are developed equally on both sides, with the exception that the left forearm (both bones) is half an inch longer than the right. Femora equal in length on both sides.

There is a prominent hump in the upper lumbar region of the spine projecting backwards. A plumb-line from its posterior part runs past the right posterior superior spine of the ilium and on the right of the sacrum, and drops an inch or so behind the right heel, and half an inch inside it. Another dropped anteriorly from the odontoid process of the axis runs in front of the left sterno-clavicular joint, 12 millimetres to the left of the sternum, corresponding to an inch to the left side of the symphysis pubis and to the ground through the internal condyle and side of left foot. Thus the weight of the trunk appears to be distributed in a vertical diagonal plane rather than in an antero-posterior one. A horizontal line from the hump through to the sternum runs *parallel* to the lower 6 dorsal vertebræ from behind forwards, and strikes the sternum 6 centimetres from the top.

Skull.—Ridges for temporal fascia well marked. Rather more than the posterior half of the sagittal suture is obliterated. Some small wormian bones occupy part of the lambdoidal suture.

The left malar prominence and superior maxilla have rather larger proportions on the left side than on the right, and the face for this reason looks a little one-sided; the left orbit being at a slightly higher level than the right. Its size is not diminished.

Foramen Magnum and Spine.—The atlas is firmly ankylosed by bone to the base of the skull throughout the whole of its left lateral half. It has an irregular spiculated surface behind, but fuses the two surfaces, that of the anterior part of the atlas and the basal surface of the basilar process, completely in front. The right half is also ankylosed in front and about the lateral and transverse process, but the lamina is still separate from the occiput. It is also to be noted that the two laminæ do not close behind, but leave a chink three millimetres wide where the tubercle of the spine should be, and again in front, running deeply into the substance of the bone beneath the articular facet for the odontoid process, slightly to the right of the median line, is a cleft in the bone not extending through its whole thickness. The lateral masses have ossified, and gradually projected upwards and downwards (or backwards and forwards) to form the vertebral ring or neural canal, but they have completely failed to close behind, and have only partially succeeded in front. A similar specimen is to be found in the Guy's Hospital Museum, 1000^{20}. The bone is there in two symmetrical halves, not having closed either in front or behind. Farther down the spine, in the rest of the cervical region, the bodies of the vertebræ are all very irregular, with shelving outgrowths of bone at the edges of the articulating surfaces, much as is seen in the diseased state known as osteo-arthritis. The axis and third cervical are completely fused in front, and the seventh cervical and first dorsal lower down. The axis and third cervical are united throughout their bodies, articular surfaces and laminæ, with the further abnormalities:—

1. Absence of the posterior segment of the third left transverse process, so that the process as a whole is represented by a spike of bone, corresponding to a rib in the dorsal region. It is slightly curved like the other anterior transverse processes, and firmly ankylosed to the body of the vertebra.

2. The second left transverse process is as it were pressed out, and has a very large foramen in it some eight millimetres diameter. It seems probable that this second transverse process really represents itself and part of that belonging to the next vertebra, that it is a double one. Further, the left upper articular surface of the axis is at a slightly higher level than that on the other side, while the corresponding lower articular surface of the third vertebra is well on the lamina not far from the spine. By these varied distortions the spinal canal is altered in shape, being deeper antero-posteriorly on the left than on the right side of the median line, and at the same time narrower from side to side.

The next vertebræ which invite attention are the seventh cervical and the first dorsal. Premising that there is a general bony ankylosis along the front of the bodies from the seventh cervical to the fourth dorsal inclusive, rendering it difficult to distinguish the various vertebræ along their front aspect, it is specially noticeable that the left half of the seventh cervical, and corresponding segment of the first dorsal, are in a somewhat rudimentary condition. The two are fused into one, and from the upper part of the lateral aspect comes a cervical transverse process from the lower, immediately below the line of junction of the two vertebræ, still visible by a horizontal ridge, and precisely in the line of the lower ribs, a rudimentary first rib projects. It is ankylosed at both its extremities, internally to the body of the vertebra, externally to the cervical articular process. It is $2\frac{1}{2}$ centimetres in length. It can hardly be said to have any definite parts. It articulates by a bulbous end with the body of the vertebra, in linear series with the other ribs. About a third along it becomes very slender, enlarging again somewhat at its termination by fusion with the anterior part of the cervical transverse process (Plate, Fig. 2, *b*). The posterior aspect of the seventh cervical and first dorsal, Plate, Fig. 3, also shews a complete ankylosis on the left side, but not on the right, and thus it happens that the two laminæ of the seventh cervical do not meet in the median line: that on the right side ends singly in the spinous process. (Fig. 3, *a*.) It would of course follow that with vertebræ in this rudimentary condition, one side being normal and the other but small and displaced, a gap would be left in the vertebral ring corresponding to the deficiency caused by the rudimentary parts. This is so to a limited extent. But lateral curvature, as usually happens, has in some measure closed the opening, and its existence is further rendered still less apparent by an overgrowth in a downward direction of the lamina above, and in an upward direction of the fused vertebræ below (*vide* Fig. 3). Unilateral fusion of the vertebræ and arrest of development may also be noticed farther down: the second and third ribs on the left side come off together, the one immediately below the other, and the two are ankylosed together. (Fig. 3, *c*.) Posteriorly they attach to a broad common transverse process. The laminæ and spines of the second and third vertebræ are completely ankylosed, though a ridge still marks their proper separation. In the ligament running between the spines of the first and third dorsal vertebræ is a small bony nodule, which seems to represent the spinous process of the second vertebra whose laminæ, &c. are fused with the third. (Fig. 3, *b*.)

This unilateral abnormality and fusion of the vertebræ has, as was to be expected, caused a considerable deviation from the normal in the hæmal arches. The first rib being rudimentary the second has all the characteristics of the first, *i. e.* it has a distinct ridge on its upper surface, and an eminence on its inner border for the scalenus anticus. In front and behind this are grooves as in a normal first rib for the subclavian vein and artery, and behind the latter a rough depression for the scalenus medius, while the third rib is rough and tuberculated, it may be assumed, for the attachment of the upper serrations of the serratus magnus.

The terminations of the ribs towards the median line are also very abnormal (Plate, Fig. 1). The left side of the manubrium and the facet for the left sterno-clavicular articulation are at a lower level than on the right side. The second costal cartilage, though at rather a lower level, joins the sternum pretty nearly corresponding with the junctions of the first and second cartilages on the right side. The third left rib fails to reach the sternum at all, its inner border becoming blended with the second rib, while it terminates in a rough and blunt end just in front of the groove for the subclavian vein noticed on the second rib. The next succeeding rib, therefore, which joins the sternum after the second on the left side, is the fourth, and at a point corresponding to midway between the second and third cartilages on the right side. The junction of the bone with the cartilage is flattened upwards, as if a piece of the third rib might have been tacked on to the fourth (Plate, Fig. 1). From thence the two sides alternate, as may be seen in Plate, Fig. 1. The left fifth lies midway between the right third and fourth. Left sixth midway between right fourth and fifth. The left seventh midway between the fifth and sixth. Thus down to and including the ninth, the ribs have a separate attachment to the sternum on the left side, the seventh or eighth being the last so attached on the right.

The twelfth rib is unusually large on each side, while on the left (Plate, Fig. 4*a*) a thirteenth rib is seen eight centimetres long and ankylosed to the tip of the transverse process of the first lumbar. The twelfth rib on the right side articulates with its own vertebral body, and with the under border of the transverse process of the vertebra above it.

From the fifth to the eleventh dorsal vertebræ inclusive the parts are normal. Below this, there are again much distortion and abnormality of the bones, possibly due to disease, though reasons will be hereafter adduced for thinking the condition one and the same as that existing above.

But first to describe them. The twelfth dorsal is well represented on the right side, but the left half of its body is wanting. The corresponding transverse process is still apparent with the twelfth rib, articulating with it, and perhaps the laminæ are visible behind. This is however doubtful, for the twelfth dorsal and first and second lumbar are so fused together behind into one plate of bone, that they are not separately recognisable. The first lumbar has no body at all, but on either side and behind in the plate of bone described are seen tubercles which represent probably the stunted lumbar transverse processes and the right articular process.

The second lumbar has its body wanting on the side opposite to the absent half dorsal, that is to say, the left half is in good condition, the right is absent. The transverse process on both sides is well formed. The third lumbar has a deep body, and is slightly compressed on its right side, owing to the lateral curvature, but it is not otherwise abnormal. The fourth has two lateral halves, which, failing to meet in the median line, leave a gap, and so let down the third lumbar body nearly to the fifth. The fifth lumbar is normal. The curvatures associated with such malformations of the spine as these, are, as might be predicted, various, but except in the dorsal region they are not extreme. In the lower cervical region, from the nearly complete loss of half a vertebra and the fusion and incomplete growth of other halves, there arises a lateral curve, the concavity of which is turned towards the left side. It commences at the axis and ends about the fourth dorsal. Its greatest depth is at the articulation of the first with the second dorsal vertebra, and measures 15 millimetres, the base of the arc being 13 centimetres. Below this is a very slight curve in the opposite direction, ending about the 10th dorsal. A third in the same direction as the primary one may also be said to commence, but is quickly lost in an antero-posterior or angular curvature. The latter is not consequent on the spiral twist which is so generally found with lateral curvature, but is brought about by deficiency of the left lateral half of the twelfth dorsal, the whole body of the first lumbar and the right half of the second lumbar. The deficiency of opposite halves of two bodies compensate for each other, and the absent first lumbar leads to antero-posterior curvature. At the same time there is a slight lateral curving, owing to the tendency to displacement of the upper part of the spinal column from the lower, due to the absence of the right half of the second lumbar. By this means an inclined plane sloping downwards and to the right is formed, upon which the dorsal vertebræ have slid. The deficiency of the fourth lumbar body leads somewhat to the general angular curvature, but does not produce any independent additional distortion.

The rotatory or spiral curve is slight. It is found throughout the dorsal and lumbar region. The bodies of the four upper dorsal vertebræ slightly face towards the right, the three lower ones face back again to the front. The next five repeat the primary turn, and the lumbar, the last excepted, twist very decidedly to the left.

Respecting the thoracic and pelvic cavities I have not much to say. The chest is a deep one: the antero-posterior diameter from the anterior surface of the body of the seventh dorsal to the posterior surface of the xiphoid cartilage is 18 centimetres, the transverse diameter on a level with the top of the eighth rib on the left side is 24·8 centimetres. The right side is more rounded and on a higher level than the left, which is comparatively flat in front of the angles.

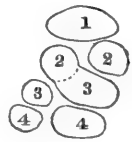
The pelvic brim has a slightly shallower curve, representing the segment of a greater circle on the left side than on the right, but the distortion is hardly appreciable by measurement. It is however noteworthy, because it would go to shew that there had been a preponderance in the weight transmitted to the left side, whereas a plummet-line points in the opposite direction. If we may assume that, given muscular action, the transmission of the body-weight in the living subject would not have been permanently altered from its present direction, this discrepancy leads me to one of two conclusions: that there has been an arrest of development on one side of the pelvis as a separate condition—and of this, save for the slight shallowing of its curve, there is no evidence whatever,—or that the arrest has been brought about by the unequal transmission of weight to the extremities consequent upon the spinal deformities. In that case the curvatures could not have been the same in younger life as those now present, since a plummet-line now drops towards the right side, while the pelvis is arrested in development on the left. The original curves may have altered under two conditions at any rate. First, as old age progressed, they may have become more pronounced, the spine settling down as it were, and carrying the weight to the side opposite to that which at first sustained the greater pressure, or disease of the vertebræ may have subsequently altered the conditions. The former explanation is, it seems to me, more likely to be the correct one; but it is thought by several who have examined the specimen that extrauterine disease has been at work as well as an abnormal developmental process, so that either may have had a share in the production of the various curves. A sketch of the lumbar region of the spine is appended (Plate, Fig. 4). It will be seen from this, and much more evidently in the skeleton, that what was noticed in the upper region—be it remembered where it is undoubtedly of intrauterine date, viz. a partial absence of parts, is also noticed in the lumbar region—one vertebra gone altogether, except tubercles, which perhaps represent its processes; a second with one half absent; the third overgrown; the fourth wanting in the mid-body, but present on either side. These are all conditions entirely consistent with the congenital changes throughout the column, while for disease it is not common, so far as I have seen, to find diseased vertebræ alternating with perfectly healthy intermediate ones.

The case next to be described also tends to confirm this opinion, by shewing, in the early condition, the state of things which I suppose to have originally existed in this adult skeleton.

It was presented to the Hunterian Museum in 1870 by Mr Jonathan Hutchinson, and is thus described in the Catalogue by Mr Lowne: "278. The skull and vertebral column, with a portion of the ribs and pelvis, of a hydrocephalic male fœtus, with distortion of the vertebral column, defective development of the occipital bone, and defective closure of the vertebral canal behind. The laminæ of the cervical and first six dorsal are widely separated behind; those of the right side are defective. There are apparently but five cervical vertebræ, and their laminæ are fused together. The head was pressed back, so that the edges of the enormously dilated foramen magnum rest on the edges of the laminæ of the dorsal and cervical vertebræ, to which they were attached by ligaments. The supra-occipital cartilage bones are very small. There are, however, two scale-like bones, representing the upper part of the supra-occipital bounding the foramen magnum above. The frontals and parietals are very large. There is spina bifida in the lumbar and sacral region. The pedicles and laminæ are well developed, but they are spread out on either side, so that the spinal canal is open behind. There was talipes of both feet."

The part to which I would specially call attention is the upper region of the spinal column. As far as can be made out the bodies of the cervical vertebræ appear to be only four and a half in number. The odd half is lowest (Plate, Fig. 5, *a*). The lateral masses are jumbled together, but six segments can be distinguished on the left side, and five on the right. The intervertebral foramina correspond on both sides (they are six in number) if allowance be made for one large one on the right side which apparently corresponds to two. The four whole bodies are each made up of two rounded or nipple-like masses, arranged side by side, and partially separated from each other by a deep groove. This is very plain anteriorly (see Fig.), and less so, but still distinctly posteriorly (Fig. 6).

The odd half occurring on the left side, or rather its other half deficient on the right side, has caused a rather sharp lateral curve with the concavity towards the right. Below the cervical bodies come what appear to be, at first sight, a normal first dorsal, then an odd half on the left side, then a whole body placed obliquely, and then again an odd half fused with the vertebra below. But this is not, I think, the correct enumeration of these vertebræ. The first dorsal centrum is normal, but between the second and third what may be called a cross ankylosis has occurred, the right lateral half of No. 2 ankylosing with the left lateral half of the third. The right lateral half of the lower vertebra is also somewhat displaced outwards owing to the curvature of the spine towards that side from the distortion above. It is also ankylosed to the corresponding half of the fourth vertebra, the latter being somewhat shallower from above downwards than the remaining vertebræ. This ankylosis is not shown in the figure. The five dorsal vertebræ next below have the distinct vertical groove, described by Professor Humphry[1], as evidence when it occurs of a double nucleus to the vertebral bodies.



In this case, excepting the spina bifida, there is no further abnormality. The last rib is wanting on both sides, but the deficiency is possibly due to the preparation of the specimen.

Another specimen in the College Museum, 289, shews a very similar and more extreme though less marked state, also associated with spina bifida and fusion of the ribs. In this it appears, however, as if an odd half vertebra in excess had been developed (a fœtal condition similar to that described by Rokitansky from an adult skeleton). A fœtal skeleton in Guy's Hospital Museum has apparently a fusion of the superimposed halves of two vertebræ on the left side about the eighth dorsal.

The last case to be mentioned is also from the Museum at Guy's. It has not been previously described, and has some points of similarity to the other cases. I will therefore reproduce the description given of it in the Museum Catalogue by the editor, Dr Wilks.

1004[91]. "A congenital malformation of the spine. This is caused by the fusion together of the bodies of the third, fourth, and fifth dorsal vertebræ, and the curvature of the new-formed mass. A slight oblique fissure passes across the anterior part,

[1] *On the Human Skeleton*, p. 123.

whereby it is seen that the body of the fourth vertebra is wholly destroyed, and the third and fifth partially so, the one more on its left side, and the other more on the right. Upon the posterior view the three transverse processes are seen to be perfect, those of the lower vertebra retaining their natural position; and respecting those of the other two vertebræ, on the right side the upper process is seen entering its proper body, and the middle one attached to a very small portion of the body of the fourth which remains. On the left side the two upper transverse processes are fused together, and join the remains of the body of the third vertebra. The three spinous processes are correct in number, and the two lower ones come off from the remains of their respective vertebræ in the usual way, but the upper spine is continuous wholly with the right arch of the third vertebra; the left arch of the bone not meeting its fellow at all (the two being developed separately), but is welded into the spinous process and arch of the vertebra below. There is a synostosis of the left transverse processes of the first and second dorsal vertebræ. The two last cervical vertebræ are also malformed with respect to their arches, those of the lower being separate. Thus upon looking at these two bones posteriorly, two spinous processes are seen; but the upper is formed not only by the union of its own two arches but also by the left side of the seventh cervical, leaving the lower spinous process to be formed wholly by the right lateral half which is placed beneath its fellow. The two vertebræ are united by their bodies and arches on the left side. This preparation came from the dissecting room, and is therefore deficient in history; it shews a congenital defect followed by a reparative process, which probably occurred during fœtal life."

I would add that the intervertebral foramen between the third and fourth pedicles is still present in the centre of the lateral mass, but it is not more than one-third the size of the others.

The case is of value for one or two reasons. In the first place, it goes to support the hypothesis of cross ankylosis between lateral nuclei, for it is best explained in that way. The bodies of the third, fourth, and fifth vertebræ are fused together; but of these the fifth is obviously perfect, and merely altered in shape somewhat by reason of the ankylosis and curvature. The fourth is described as wanting in its body, but from the setting of the transverse processes it is, I think, well represented on either side, whether by original body centres, or merely by a growth forwards of that part which helps to make up the body, but comes from the lateral masses, is very difficult to say. However, on the left side it seems that the body of the third is rather wanting, on the right side that of the fourth. The right half of the third and the left half of fourth constitute the chief portion of the fused mass, and in the concavity of the curve is a squeezed-down half third body, in the convexity a pushed-out larger half body of the fourth dorsal. This description also tallies with what is observed behind: the main (right) half of the third vertebra has the lamina and spine perfect, but the left or small half, is merely an appendage to the upper border of the fourth, and does not meet its fellow in the median line.

Then again, the case is of interest because of the implication of more spots than one. It will have been noticed from the description that the seventh cervical has a tendency towards non-coalescence of its laminæ in the median line behind. This may serve to suggest that the upper part of the axis has received a twist, and the corresponding laminæ of the neural arches have consequently not been thrown across at the same level.

Of the correctness of the inference that the deformity dates from fœtal life, there can be no question; both the character of the changes and the similarity in the results, as seen both in adult and fœtal skeletons, sufficiently attest it.

Such cases are not common. Rokitansky quotes three which are allied to them, one a case of intercalation of supernumerary lateral halves of vertebræ, another of deficiency of lateral halves, the third of want of closure of lateral halves of the bodies in the median line; a precisely similar condition to the lumbar deformity in the adult skeleton described in this paper, and leading to a similar result, viz. angular curvature.

In discussing the question of the number of nuclei in the body of a vertebra[1], Professor Humphry mentions a few other cases, one of them in the Hunterian Museum (277 Terat. Cat.), a fœtus whose lower spinal column is cleft in twain. He brings them forward as suggestive "that in the complete or typical vertebra two nuclei should be allowed to this part (*i.e.* vertebral body), one on either side of the median line." The fœtal skeleton described in this paper seems to support the conclusion to which he comes, "that there is sufficient evidence of the occasional development of the vertebral bodies from two nuclei laterally disposed." With the cervical vertebræ still deeply grooved, and the right half of one body united to the left half of its inferior neighbour, what other explanation is so probable?

On the other hand, Professor Flower has found no evidence from the study of *normal* anatomy, and from which alone he thinks an opinion ought to be formed, of the occurrence of a double nucleus to the vertebral bodies. Humphry quotes Muller's opinion also, "that the form of the centre of ossification of the body of a vertebra is bilobed." If this is so, the grooved appearance down the centre of the spine in some cases would be explained without having recourse to the opinion that a double nucleus occurs. But both the one and the other are, it would seem, not improbable, various degrees of the same want of development, and perhaps the bilobed or less extreme condition, is not so very uncommon. Do they suggest the formation in some cases of the rudimentary centre around the temporarily persistent chorda dorsalis, the perfectly double nucleus being the more pronounced condition? Supposing this to be so, it is not inconceivable that occasionally the rudimentary state should be the persistent one, producing what might almost be called a reversion to the lower type of spinal axis with its amphicælian vertebræ and persistent chorda; occasionally, the asymmetrical development of halves of the centra only. In cases where the latter obtained both hæmal and neural arches would likely enough be interfered with in their budding, and would close improperly or asymmetrically. This is perhaps the explanation of the abnormalities in Cases 1 and 2. The fusion of parts is, I think, consequent upon the malformation, and is often no part of the primary

[1] *Loc. cit.*

state. It usually occurs in the concavity of the arc, that is to say, where the pressure upon the bones is greatest, where they are brought close together by the absorption of the intervening substances. The bony surfaces being brought and kept in contact, ankylosis may, we know, be predicted with much probability, and on the other hand it may be said that fusion of two lateral superimposed halves of the bodies of vertebræ does not necessarily bring about curvature. This is shewn by a specimen in Guy's Hospital Museum 2541^{70}, in which about the eighth dorsal the vertebræ are ankylosed without producing any distortion. The same curvature would also tend towards producing the fusion of the ribs as well as of the spine, occurring as it does on the side of the concavity of the arc; but some further explanation is perhaps needed in their case. For instance, No. 322A in the Hunterian Museum is the skeleton of a fœtus which has no arms, and the first rib is seen to pass under the clavicle midway, and join to the second by a fibrous membrane just behind its chondrocostal articulation. This case, and my own, where the rib has failed to reach the sternum, rather suggest some early abnormality in the segmentation of the muscle, or non-ossification of some primary membranous intermuscular septum, such as is described by Professor Humphry [1].

To conclude then, the cases detailed all seem to render this position probable: that cases of asymmetry of the two sides of the spinal column are due to *original malformation* of the bodies of the implicated vertebræ in the direction of a bilobed or double nucleus, and the subsequent unequal growth of the two halves. By original malformation I mean arrest of development in its strictest sense, not merely its wider application as included under teratological study, which comprehends all congenital abnormalities whatsoever, whether of disease contracted during intra-uterine life, or pure malformation. Teratology includes diseased conditions with the others, probably because the difficulty has been so great to decide what was disease and what was not. It may be as well to repeat that these very cases admit of either interpretation, and Case 2 is indeed catalogued by my friend Mr Lowne as one of disease

[1] *Observations on Myology.*

occurring in the intra-uterine life. If this be correct, the most obvious explanation of the conditions would appear to be that of a primary lateral curvature of the spine, not so very unlikely a thing to happen, one would think, under various circumstances, such as hydrocephalus, or excess of cerebro-spinal fluid in the spinal canal. Such a state of things, however, does not seem to be very common; the Hunterian Museum possesses two instances of lateral curvature unassociated with other malformation, one in a calf, the other in a human female fœtus (261, 262, Terat. Cat.), and 2540^{60}, in Guy's Hospital Museum, is a fœtal skeleton with lateral curvature and spiral twist of the spinal column in association with a malformed head. There is also a male patient in Guy's Hospital at the present time, under the care of Mr Bryant, aged 26, who has a very pronounced lateral curvature associated with a cured spina bifida.

But the presence of primary curvature of the spine would not negative the occurrence of permanent distortion in consequence of a double nucleus to the bodies of some of the vertebræ. On the contrary, if lateral curvature take place from whatever cause, and the bodies of the vertebræ in such a case be developed in halves, there will be a tendency at the point of greatest pressure to protrusion or displacement of some of them, and fusion or ankylosis of others, when a spinal distortion similar to that we have described would be the result.

The nature of the supernumerary loin-rib does not require much discussion; it articulates only with what appears to be the transverse process of the first lumbar, and it must be looked upon as an abnormal development of the epiphysial tubercle of that transverse process; an occurrence which is not so very uncommon, and has been fully described before. Of more interest is its occurrence on the same side as the deficiency above: it occurs on the same side as the rudimentary rib. I was at first disposed to look upon it as the proper twelfth rib, thus ignoring the presence of the first in its dwarfed condition. The description of the parts that I have adopted was suggested to me by Professor Flower, and while it is the more philosophical, is no doubt the correct one. Is this occurrence of a rudimentary and supernumerary rib on the same side merely a coincidence, or shall it be said that nature, realizing her inability to do without the twelve, has added one below to make up the deficiency above? To solve the reason of its occurrence in this particular case it would be necessary to have the soft parts of the skeleton, and those unfortunately were destroyed, ere the rarity of our specimen could be recognised. But it will not be going beyond the bounds of probability to say that in all likelihood the two conditions were associated as cause and effect; that the first rib being virtually absent, the soft parts were in a measure shifted, or the normal segmentation of the muscular planes interfered with, and that thus some excess of muscular attachment obtained in the region of the first lumbar transverse process: that it became developed as any exostosis might do by reason of increased work bringing with it increased supplies of nutrition.

EXPLANATION OF PLATE.

Case (1).

Fig. 1. Front view of the sternum shewing the relations which the ribs on either side bear to those opposite. The figures denote the numbers of the ribs. On the left side the 1st and 3rd are not seen, the one being rudimentary, the other not reaching the sternum.

Fig. 2. Front view of the lower cervical and upper dorsal region.

a. Fused surface of the bodies of the 7th cervical and upper four dorsal vertebræ.

b. Rudimentary 1st rib.

Fig. 3. Posterior view of same region as in fig. 2. Above is seen the tilting of the lower cervical vertebræ.

a. Termination of the right lamina of 7th cervical in an odd spine.

b. Tubercle in the ligament, (?) representing the spine of the 2nd dorsal vertebra, which is completely fused with the 3rd.

c. Compound transverse process representing the transverse processes of 2nd and 3rd dorsal vertebræ.

Fig. 4. Front aspect of lower dorsal, lumbar and upper sacral vertebræ.

a. Supernumerary rib below the 12th.

The numbers and letters indicate the various vertebræ, dorsal or lumbar.

s. Sacrum.

Case (2).

Fig. 5. Front aspect of fœtal skeleton, shewing the appearance of spine developed from double nuclei in the vertebral bodies.

a. Odd tubercle (half body of vertebræ not represented on right side or behind).

The numbering and lettering explain themselves.

Fig. 6. Posterior view of the same region of skeleton. Letters and numbers the same. A spina bifida is seen above and below.

ON VARIATIONS OF THE VERTEBRAE AND RIBS IN MAN. By John Struthers, M.D., *Professor of Anatomy in the University of Aberdeen.*

Having over a number of years collected a considerable series of specimens illustrating variation of the vertebrae and ribs, I have thought that an account of them might prove interesting as a contribution to the facts of variation. Much that may appear to be mere detail will, I trust, not prove to be so to those who are engaged in the objective study of variation of these parts. It is, in truth, only after a close and critical examination that the nature and worth of a variation can be appreciated. Besides what else may appear, it will be evident from the following study, that individual variations of these parts are so frequent and may be so great, that conclusions as to characters of species, or differences of race, in order to be reliable must be founded on the examination of a series of specimens. The specimens are, I believe, all European, mostly obtained from my own dissecting rooms.

(A) Variations in the Cervical Region.

(a) Deficient ossification of the Atlas; anterior arch, posterior arch, transverse processes.

(b) Bridges of bone developed on the Atlas, over the nerve and artery. 14 cases.

(c) Consolidation of the Atlas and Occipital bone.

(d) Case in which the Muscles of the spine of the Axis are transferred to epispinous bones at the 3rd vertebra.

(e) Variation in the place of entry of the Vertebral Artery in the cervical vertebrae. 2 cases of artery entering foramen of the 7th, and 3 special cases.

(f) Additional foramen in the cervical transverse processes. Examination of numerous cases.

(g) Variation of 7th vertebra; lateral foramen, transverse processes, costal facets.

(h) Cervical Ribs. Examination of 10 cases illustrating the various degrees of development.

(i) Recognition of Cervical Ribs in the living body. 3 cases.

(B) Variations in the Thoracic Region.

(a) Imperfect development of 1st thoracic ribs. Case with remarks. Case in a three-toed Sloth.

(b) Varieties of the Sternal Ends of the ribs. 5 cases.

(c) Variation of the Costal Facets of the 9th and 10th dorsal vertebrae.

(d) Imperfect development of the 12th rib. 5 cases.

(e) Variation in the place at which change of the Articular Processes occurs. 10 cases. Note respecting position of this change in animals.

(C) Variations in the Lumbar Region.

(a) Cases 1 and 2, Lumbar Rib simply. Note of 2 cases in the Ox, differently placed.

(b) More complex lumbar variations; Vertebrae and Ribs.
Case 3. Dorso-lumbar vertebra more than usual, with additional pair of ribs. Note of another case of the same in Man, and of case of the same in a Cat.

4. Case of the same, with 6th lumbar vertebra partly sacralised.

5, 6 and 7. Three cases of 6 lumbar vertebrae.

8. Dorso-lumbar vertebra less than usual; 11 pairs of ribs, and 12th rib, or movable transverse process, on one side.

9. Case of 6 cervical vertebrae, and 6 lumbar vertebrae; and a vertebra suppressed in some part of the column.

(c) Variation of the 5th lumbar vertebra.

(1) Changes by which it becomes united to the sacrum. 4 cases. Note on this change in the Gorilla.

(2) Variations of its lower Articular Processes. Cases and remarks.

(3) Variations of the upper articular processes of the sacrum.

(D) Variations of the Sacrum.

(a) Diminution in the number of its component vertebrae.

(b) Variation in form of the upper sacral vertebra, apparently from borrowed lumbar vertebra. The Ape-like sacrum. 4 cases.

(c) Examination of 6 sacra, in which the upper vertebra is of unusual form, but in which the additional vertebra appears to have been obtained from the coccyx.

(d) Examination of 7 other cases in which a 6th vertebra is obtained from the coccyx.

(e) Variation in the number of sacral vertebrae with which the Ilium articulates.

(f) Variation in the form of the Auricular Surface.

(g) Case of Sacral Canal open in its whole length.

(E) Variations of the Coccyx.

(a) Diminution in the number of its component vertebrae. Cases of, and their nature.

(b) Increase. Remarks. Two cases of 10 sacro-coccygeal vertebrae.

(c) Union of the coccygeal vertebrae. External influences.

(A) Variations in the Cervical Region.

(a) Deficient ossification of the Atlas. Case 1. *Anterior arch mostly ligamentous, and containing a separate ossification.* This preparation is from a female subject aged 91. The gap in the bone is $\frac{3}{4}$ inch at the upper margin, $1\frac{1}{8}$ inch at the lower margin. It is occupied by a ligament flattened like the normal bony arch but not so deep. A scale of bone, $\frac{3}{8}$ inch in length, $\frac{1}{6}$ inch in height, lies in the right half of the ligament, having a distinct interval of ligament on its right side also. The edges of the gap are formed by two pointed processes which project for $\frac{1}{4}$ to $\frac{1}{3}$ inch inwards beyond the articular cavities. The fore ends of these cavities converge less than usual, being nearly as wide apart as the hinder ends are at their inner edge. The posterior arch, and the other parts of the bone, are well ossified and healthy looking. The odontoid process presents a raised platform against which especially the scale of bone has played.

Case 2. *One half of posterior arch of Atlas represented by a ligament.* An adult male subject. The rest of the cervical vertebrae well ossified and robust. The left side of the arch is well ossified, ending abruptly a little to the left of the middle line, where it attaches the ligament. The entire right half arch is ligamentous, including the part which represents the pedicle. The anterior transverse process of the same side is slender, tapering outwards, and is then ligamentous opposite the outer part of the foramen.

Case 3. *Mesial deficiency of posterior bony arch of Atlas.* The bone is otherwise robustly developed. The gap is about

$\frac{1}{4}$ inch, the left arch ending abruptly, the right obliquely on its upper edge. Both half arches are well ossified, and the additional small foramen is present on both sides, about the size of a crow-quill, but oval. In the case of cervical rib No. 6, adult and the vertebrae robust, the two half arches of the atlas are just meeting by irregular ends, but are not united.

Deficiency of one of the transverse processes of the Atlas. In all the adult specimens of this deficiency before me, it is of the anterior process. In a female subject (case No. 1, lumbar variation) it is deficient externally on both sides. In a female skeleton, it is deficient on the right side in its outer half. In a male, aged 31, the neck otherwise well ossified, the outer half is deficient on the right side. In another case (case No. 4, cervical rib) the deficiency is of the outer part on the left side. At the same time it may be remarked that, in several of the specimens before me in which there is decided inequality of the two processes, the slender one is the posterior. This is partly owing to the posterior being more slender than usual, partly to the anterior process being unusually robust.

(b) Occasional bridges of bone on the Atlas over the groove for the nerve and artery. Two of these bony arches may occur, the nature of which may be readily understood by referring to the conditions presented by the more tube-like atlas of quadrupeds, and to the position of the sub-occipital nerve and vertebral artery, and the fibrous bands, in man. The *posterior bridge* is common and well known. It is represented normally by a strong fibrous arch. It curves from the back of the condyloid cup downwards and backwards to join the hinder edge of the arch, at a point where the two stages of the arch representing the pedicle and the lamina meet, thus converting the superior notch of the atlas into a foramen. I may note briefly the conditions in thirteen specimens of this variety before me, five of these being in cases to be referred to afterwards for other varieties.

1. Robust atlas; bridge on both sides; broad, being $\frac{1}{6}$ inch in breadth at the middle.

2. Robust atlas; bridge on both sides; narrow, especially on right side.

3. Small atlas; bridge on both sides; about $\frac{1}{8}$ inch broad.

4. Female, aged 40 (case of cervical rib No. 5); bridge on both sides; an oval aperture in each arch near outer edge.

5. Male, aged 47 (case No. 4 of imperfectly developed 12th rib); on left side $\frac{1}{4}$ inch broad, with oval aperture in it $\frac{1}{8}$ inch long. On right side, incomplete at middle.

6. Male. Complete but narrow on left side. On right side, only a spur-like process hanging down from condyle.

7. Male. On right side, $\frac{1}{8}$ inch broad. Left side of atlas removed.

8. Robust atlas. On right side, complete and narrow. Left side a pointed process from above, very little from below.

9. (Case of cervical rib No. 4.) On right side complete, $\frac{1}{10}$ inch broad. Left side a pointed process from above, very little from below.

10. Robust spinal column. (Case No. 8, lumbar variation.) On right side two pointed processes nearly meeting at the middle. Left side the processes short and of about equal length.

11, 12, and 13. Three specimens (one of them case of cervical rib No. 6). Represented on both sides by an overhanging spur from the condyle and a slight ledge on the arch.

The *lateral bridge* is seen in the first of the above 13 cases. It passes from the outer edge of the condyloid cup, outwards and downwards to join the back part of the transverse process external to the foramen. Above, it is nearly half an inch in breadth, narrowing downwards to about $\frac{1}{8}$ inch. This is on the left side. On the right side, it appears to have had exactly the same arrangement but is broken. In the eighth of the above 13 specimens, the lateral bridge is about half formed on both sides, mainly from above. In another atlas it is fully half formed; on the left side, by a broad ledge projecting from above, and by a shorter pointed process from below, while on the right side it does not exist; nor on either side is there any part of a posterior bridge. While the posterior bridge adds one foramen to the atlas, a transverse one, the lateral bridge, arching over the vertebral artery as it ascends from the lateral foramen, gives the appearance of other two foramina, antero-posterior in direction[1].

(c) Case of Consolidation of the Atlas and Occipital Bone. The first impression on seeing this specimen is that the condition is the result of former disease, but Professor Henle shewed me some years ago, in the Anatomical Museum of Göttingen, several specimens of the same condition, and he did not consider it as of pathological origin. There is no history to this case. It occurs in a prepared set of bones of the head. It is adult, as the basilar process had been united to the sphenoid; but not old, as the bones have all separated well at the sutures; and, from the appearance of the frontal bones and the jaws, is probably from a female.

The ankylosis is not merely articular, but fills up the anterior and posterior spaces, making the consolidation continuous; and, although there are vascular foramina here and there, there is no irregularity or excrescence, but a general appearance of healthiness. There is also shortening longitudinally, as if the occipital condyles had not been developed; the transverse processes of the atlas being $\frac{1}{8}$ to $\frac{1}{4}$ inch, instead of $\frac{1}{3}$ to $\frac{1}{2}$ inch, from the parts of the occipital bone above them, and the measurement taken from the lower edge of the anterior condyloid foramen to the centre of the inferior articular surface of the atlas being 8 to 9 lines instead of about 12 lines. No trace remains of the line of union of the articular surface. The tubercle and form of the anterior arch of the atlas are visible, but the bony continuity between them and the basilar process is not much thinner than the arch itself. It is pierced close to the left of the middle line by a vascular foramen which would admit a thick pin. The union of the posterior arch to the occipital bone is by a thinner plate of bone, in which, to the right side of the middle line, there is an irregular gap, left unossified, 3 lines across and 1 line in height. The posterior arch itself is much thinner than usual and without any rudi-

[1] Were the fibrous membrane which here covers over the vertebral artery between these two bridges also ossified, except the perforation in it which transmits the posterior division of the nerve, we should then have the condition of parts presented by the atlas of a baboon (cynocephalus porcarius) now before me, marking off a more definite posterior foramen.

mentary spine. The lateral foramen of the atlas is, on the left side, wide, embracing a full-sized round part internally and an irregular part externally, the two transverse processes meeting externally only by a narrow bar; on the right side they do not meet from deficiency of the anterior process. The foramen for the sub-occipital nerve and the vertebral artery is situated just behind the condyle, is rounded and scarcely so large as an average foramen for the vertebral artery. From the outlet of the anterior condyloid foramen, on both sides, a well-marked groove leads backwards to above the lateral foramen. It is smooth and sharp-edged, deep enough to form half a canal, wide enough to contain an under-sized vertebral artery, and appears as if it had transmitted something from the anterior condyloid foramen, but that foramen itself is below the average in size and scarcely so large as the groove would be if completed into a canal. Some occipital bones shew an irregular groove running backwards from the outlet of the anterior condyloid foramen. The articular surfaces for the axis are very fully developed, the facet for the front of the odontoid 6½ lines across by 5 in height, and the inferior articulating surfaces of the atlas are above the average in size.

(d) CASE IN WHICH THE MUSCLES OF THE SPINE OF THE AXIS ARE TRANSFERRED TO EPISPINOUS BONES AT THE SPINE OF THE 3RD VERTEBRA. The spine of the axis wants its usual great size and is not bifurcated. Recti minores muscles normal. Interspinales absent as usual between atlas and axis, but present between axis and 3rd. The recti majores arise entirely at the spine of the 3rd vertebra. The inferior oblique also arises at the spine of the 3rd, but an additional portion, equal to ¼ the size of the lower, arises from the axis, deeper than the spine, and passes to join the greater portion above its middle. Superior oblique normal. At first the muscles attached at the spine of the 3rd vertebra seemed as if directly attached to a massive spinous process, but on dissection it was seen that they are attached to a pair of movable ossicles.

These epispinous bones are oval and flat, like small-sized almonds; length 6 to 7 lines, breadth 3 to 4 lines, thickness 1 line; the left being somewhat larger in all directions than the right. They are attached to the corresponding tubercle of the spine of the 3rd vertebra, each by a strong, short, deep, ligament, and to each other by transverse ligamentous fibres passing between their inner margins. On dividing the latter, the ossicles can be moved outwards to $\frac{3}{4}$ inch from each other, and can be moved freely in all directions. The deep ligament is attached to the inner part of their deep surface, the muscles above mentioned to their upper end and outer surface. The spine of the 3rd vertebra is more developed than usual, the left tubercle being the larger. The interspinales in the space between the axis and 3rd vertebra are large and in two strata; the superficial, flattened laterally, diverge downwards and are attached to the deep surface of the epispinous ossicles and to the deep ligament; the deeper pair are parallel and more like ordinary inter-transversales. The fibres of the two sets blend at their attachment to the spine of the axis. The muscles which normally pass from below to the spine of the axis, were attached to the lower part of the epispinous ossicles.

When the ossicles are approximated, as they lay naturally, they form an elongated saddle-like covering to the 3rd spine, and can be moved freely (to the extent of half an inch) upwards and downwards, the deep ligaments then checking. In life, the preliminary action of the muscles from below would be required before the rectus major and inferior oblique could have a fixed point from which to act. It would appear that these ossicles represent the tubercles of the spine of the axis, developed separately and carried down to the spine of the vertebra below, carrying all the muscles with them, except those deeper fibres of the inferior oblique which may be seen to arise from the lamina rather than from the spinous process proper. In other respects the cervical vertebrae are normal, except that the 7th has carried its ribs longer than usual before they became ankylosed, especially on the right side.

(c) Variation in the place of entry of the Vertebral Artery in the Cervical Vertebrae. I may note under this head, as worthy of mention, two cases in which the vertebral artery entered the foramen of the 7th vertebra, and three special cases of the artery, as not unfrequently occurs, entering higher than the 6th vertebra.

Case 1. *Left vertebral artery entering at the seventh vertebra.* Aged male subject. Artery arose nearly an inch earlier than usual from the subclavian, and entered the foramen in the transverse process of the 7th cervical vertebra. On right side, artery arose normally and entered at foramen of 6th vertebra. The bones have not been preserved.

Case 2. *Right vertebral artery arising last from the arch of the aorta, and entering at the seventh cervical vertebra.* Male subject, aged about 15 years. The right vertebral arose from the back of the aorta half an inch after the origin of the left subclavian. It passed obliquely up and across between the gullet and the first dorsal vertebra, and entered the foramen in the transverse process of the seventh cervical vertebra on the right side. The artery was of the normal size. This case occurred in 1854, and I cannot say more of the other arteries than that it is entered in my note-book at the time that they were normal. The macerated vertebrae are in my collection. On the right side, the foramen is large and rounded, not far from twice the capacity of the foramen of the vertebrae above it. Its anterior boundary is formed by a completely ankylosed rather narrow bar, bulged forwards, and without a tubercle. On the left side, the foramen is less than half the size of the right, and smaller than that of the vertebra above it. The cervical rib forming this boundary is not fully ankylosed, either at its inner or outer end; nor is the ossification of the 6th transverse process of this, the left, side completed, a narrow fissure still remaining along the middle of the nerve-groove.

The origin and course of the right vertebral artery in this subject, before it reaches the foramen, shew that the case falls to be classed with that interesting variety in which the right subclavian trunk arises last from the arch of the aorta, representing the remains of the embryonic right aortic root, four specimens of which are in my possession. One of these has the bones attached, and on both sides the vertebral artery is seen to enter at the foramen of the sixth vertebra, both arteries arising from the subclavian trunks a little earlier than usual. In regard to the artery not normally entering the foramen of the seventh vertebra, the remark may be true enough that that would be out of its direct road, but it by no means follows that a lower origin of the artery will alter the result. It is very common for the left vertebral artery to arise from the aortic arch, between the carotid and the subclavian, but I have never yet seen it in such cases enter at the seventh vertebra. In endeavouring to understand this point one must think of where these arterial arches were in the embryo, not where they ultimately arrive at, and also of the early condition of the neck.

Case 3. *Left vertebral artery arising from the arch of the aorta, and entering at the fifth cervical vertebra.* The right was not noted, but both foramina of the 5th vertebra are equally full-sized and round, while on both sides of the 6th the foramen is scarcely half-size.

Case 4. *Right vertebral artery entering at the fourth vertebra, with other peculiarities.* Preparation of the four lower cervical vertebrae with the arteries. Although it was noted that the artery did not enter till the 4th, the foramina of the 5th and 6th are of good size and rounded, though not quite so large as those of the 4th. On the left side the artery entered at the 6th, but the anterior transverse processes of the 5th and 4th are deficient, a ligament bridging over the gap. Nevertheless, the anterior tubercles of these two transverse processes (supported from the posterior processes) are well developed, as are also their fellows of the right side and those of the 6th vertebra. Foramina of 7th oval and unequal; left not much less than the foramina above it; right about a third the size of the left.

Case 5. *Bony obliteration of the lateral foramen in the sixth vertebra, on one side.* Preparation of the six upper cervical vertebrae; moderately robust; no history. All the other foramina are full-sized and round. On the left side of the 6th, instead of a foramen there is a plate of bone. There is no mark, or thinness, to indicate a filled-up foramen. Anterior tubercle better developed than usual on this side; on the other side less than usual.

(f) ADDITIONAL FORAMEN IN THE CERVICAL TRANSVERSE PROCESSES. In 15 specimens of double foramen before me, in detached cervical vertebrae, other than the 7th or atlas or axis, nearly all, so far as appears, from different subjects, the double foramen is by the addition of a small one behind the ordinary foramen; except in one vertebra, in which, on one side, there is an hour-glass contraction marking off two foramina, of which the posterior is somewhat the larger. This frequent small additional foramen is situated opposite the middle, or a little external to the middle of the normal foramen, separated from it by a narrow bar of bone, sometimes only by projecting points, leaving it as a notch in the macerated bone. It is more or less straight in front, deeply convex behind, and therefore wants the rounded form of the great foramen. It varies much in size, in most about the size of the average foramen spinosum of the sphenoid, in some twice as large, in some reduced to the size of a thick pin. In nine of these specimens it is present on one side only, as it so happens in six on the right side, three on the left; in the remaining six on both sides, in three of them of about equal size on the two sides, in the other three considerably smaller on one side than on the other. It is largest in large-sized vertebrae, but is of good size in some that are not large. It is not formed at the expense of the greater foramen, although in some the latter may be a little less rounded at the dividing bar; nor do the two foramina, on the same side, appear to bear any relation to each other in size apart from the influence of the size of the bone. Thus the large foramina may be symmetrical while the small ones are not, and in the vertebrae in which it is present on one side only, the greater foramen is sometimes larger sometimes smaller than its fellow of the other side, as often the one as the other.

It is variously present as follows in 18 of the sets of cervical vertebrae before me.

1. On right side present, as a notch, in atlas, 3rd, 4th and 5th. On left side present in the four lower vertebrae, smallest in the 5th, in the 4th and 6th of good and equal size, and somewhat smaller in the 7th.

2. On right side in 5th and 7th, the intervening sixth ordinary foramen unusually large on this side. Left side, in atlas, 4th, 5th, and 6th, increasing downwards (vertebrae of case of ligamentous posterior arch of atlas. Case 2).

3. As a notch on both sides of 4th and 5th, and on right side of 6th and 7th. (Case of cervical rib No. 4.)

4. On both sides of 5th and 6th, and on left side of 4th, increasing in size downwards.

5. A young spine, 20 inches in length. As a notch, present on both sides of atlas, and on right side of 5th; on both sides of 6th, as a large foramen on right, as a large notch on left side.

6. As a small foramen on both sides of 5th; as a good-sized notch on left side of 6th.

7. Female subject, aged 17 years. In atlas on left side, and in 6th on both sides.

8. As a small foramen on both sides of atlas, as a notch on both sides of 6th.

9. In atlas on both sides, on right as a notch; and on right side of 6th as a foramen of good size. First dorsal vertebra on both sides presents a well-marked semilunar notch at the corresponding place. (Female subject, case No. 1 of lumbar variation.)

10. As a notch on both sides of atlas, on right side of 6th as a deep notch. Normal foramen much larger on this than on left side. (Case No. 4, lumbar variation, male aged 29.)

11. On both sides of 6th, right large, left small; and on left side of 7th as a notch. Robust spine. Atlas wanting.

12. As a notch on left side of 6th, and right side of 7th. (Case above noted in which right vertebral artery entered the 7th foramen.)

13. Preparation of two lowest cervical and first dorsal vertebrae. Present on both sides of 6th symmetrically as small foramen; on left side of 7th as a notch, and on right side of corresponding part of 1st dorsal vertebra as a notch.

14. On both sides of atlas as a notch, and on right side of 7th as a deep notch.

15. As a notch, on both sides of atlas and on both sides of 7th. Male subject (case No. 4 of thoracic variation).

16. Present on both sides in 4th, 5th, and 6th, on the 4th as notches only. On left side of 6th the anterior of the two foramina is the smaller, being about $\frac{1}{3}$ the size of the posterior. The latter, however, corresponds in position to the additional foramen in the vertebra above it. The artery has evidently not entered till the 5th on this side, and the aperture of the 6th has been minimised. The 7th vertebra carries ribs, and on both sides the lateral foramen shews a notch equal to the posterior third of an oval foramen. (Case No. 9 of lumbar variation.)

17. On both sides of 6th, as a notch. On left side of 7th as a foramen, oval transversely, long diameter $\frac{1}{8}$ inch, and from a third to a half less than the anterior foramen. On right side one foramen irregularly oval antero-posteriorly, like the two on the left side without the dividing bar.

18. On left side of 4th, as a notch; on right side of 5th as a notch. On both sides of 6th, on right side as a notch, on left side as a foramen larger than the one in front of it. The anterior small and oval, about the size indicated by the notch on the left side. The posterior three times the size of the anterior but not half the size of an ordinary lateral foramen. The vertebral artery, entering normally on the right side, has on the left side evidently not entered till the 5th, and the anterior foramen of the 6th has been minimised, and is bounded in front by a very thick anterior transverse process, about three times as thick as the corresponding process on the right side, or as the process of the vertebra above it.

Summing up these details, it appears that in these 18 subjects in which the posterior lateral foramen occurs, it is present in the *sixth* vertebra in 16 of them, on both sides in 8, on only one side in 8, of which 3 were on the right, 5 on the left side; and of the whole, the foramen was complete in 14, represented as a notch in 10. In the *seventh* vertebra it was present in 10, on both sides in 2, on only one side in 8, of which 4 were right, 4 left; and of the whole, the foramen was complete in 3, as a notch in 9. It may also be present in the first dorsal vertebra. In the *fifth* vertebra it was present in 8, on both sides in 6, on only one side, the right, in 2; and of the whole, it was complete in 9, as a notch in 5. In the *fourth* vertebra it was present in 6, on both sides in 3, on only one side, the left, in 3; and of the whole, it was complete in 3, as a notch in 6. In the *third* vertebra, it was present in one alone, being on the right side only and as a notch. In none of my specimens is it present in the axis. In the *atlas* it was present in 9, on both sides in 6, on only one side in 3, of which 1 was on the right, and 2 were on the left; and of the whole it was complete in 5, as a notch in 10. Throughout the neck, in these eighteen subjects, it was 25 times present on both sides, 27 times on one side only; when present on one side only, it was the right side in 12, the left in 15; and in the whole, whether double or single, it presented itself 36 times as a complete foramen, 44 times as a notch.

Its *situation on the atlas,* it is to be remarked, is different, being separated from the normal lateral foramen by the posterior transverse process. It is, however, still in the course of the vertebral artery. It might be taken to be in the pedicle, but more strictly is formed by a bar of bone reaching from the posterior transverse process to the pedicle. Hence in the case of the atlas, in contrast with the lower vertebrae, the posterior boundary of the additional foramen is the more or less straight one.

(g) VARIATIONS OF THE SEVENTH CERVICAL VERTEBRA; LATERAL FORAMEN, TRANSVERSE PROCESS, COSTAL FACET. I refer here to the transverse process after the normal cervical rib, which exists in early life in the human body, is fully ankylosed.

The *foramen* is generally described as small, and the process as not bifurcated. It may be so perhaps most frequently, but it is very common to find the foramen as large as or larger than those in the vertebrae above it, and to find the transverse process with an anterior tubercle. The varieties of the foramen may be referred to two forms. In the one, it is small and more regularly formed, round or more or less oval transversely, the anterior boundary of the oval with a tendency to be less bent than the posterior. The bar of the anterior transverse process in front of the foramen is then generally thick. In the other form, it is large and irregular in shape, but generally pointed externally, or prolonged as a fissure. The anterior transverse process is then generally slender and flattened and more or less bent forwards. But between these there are intermediate forms and some exceptions. The foramen may be as small in its long axis as $\frac{1}{12}$ inch, or as large as $\frac{1}{3}$, or even $\frac{3}{8}$ inch. A little over $\frac{2}{8}$ inch may be taken as the average transverse diameter of the lateral foramen in the other vertebrae, but it varies very much. Want of symmetry also is common, and probably this generally corresponds to difference in size of the right and left vertebral artery, the foramina above the 7th being generally functionally adapted. But want of symmetry appears to be more common in the 7th, as we should expect. In one set of cervical vertebrae before me, however, the foramina in the 7th are larger on both sides than those in the vertebrae above it, and are unusually oval in form and not very unsymmetrical. Although this foramen, or space, may be large and even not very irregular in form, it would not be safe to conclude that therefore the artery had passed through it. As noted above, it is not uncommon to find a notch at the back of this foramen, representing the additional foramen.

The *anterior transverse process* generally presents a rudiment of an anterior tubercle, and often a well-marked tubercle. The rudiment is represented by the ridge which bounds the nerve-groove internally, continued from the upper edge of the process. This ridge may rise upwards and outwards into a distinct anterior tubercle, giving the process a bifurcated character. There are before me seven specimens of bifurcation from well-developed anterior tubercle. Two of them are in young spines (each 20 inches in length), one of them with large oval foramen and slender anterior boundary, the other with middle-sized oval foramen and thick anterior boundary. Of the adult specimens, two have small foramina and thick anterior process; the other three have pretty large and well-rounded foramina. Even in the best developed it is narrow and pointed as compared with the tubercle of the sixth vertebra, the tubercle which meets the finger in the dissection of this part of the neck. In only one of my specimens (case of cervical ribs ankylosed on both sides—case 7a) is the anterior tubercle of the *sixth* vertebra but slightly developed, and that on the right side only, and the foramen on that side is very small, while it is full-sized on the other side and in all the vertebrae above.

Costal facet. According to my observation it is rare to find a facet on the 7th cervical vertebra for articulation with the head of the 1st thoracic rib, more rare than the expressions in books imply. Apart from cases of supernumerary cervical rib, it is present in only two of my specimens, and that on one side only; one on the left side, one on the right. In the latter, the facet is about half the size of the neighbouring one on the 1st dorsal vertebra. The head of the 10th rib articulates with the 9th vertebra in this case also on the right side, but not on the left. In the other case, the 10th rib does not touch the 9th dorsal on either side. It is, however, common among quadrupeds to have the 1st rib articulating with the 7th cervical vertebra as well as with the 1st dorsal, and as the foramen is often wanting at the same time, this vertebra then has not the character of a cervical, and has the character of a dorsal, according to the definitions of human anatomy.

(h) CERVICAL RIBS. I shall notice my various specimens in the order of development.

Case 1. *Preparation shewing rudiments of Cervical Ribs on the 6th and 7th vertebrae, in a male subject aged four years.* The preparation includes the cervical vertebrae, and the first four dorsal vertebrae with their ribs. On the *sixth* vertebra the cervical rib, or separate bony element, forms the lower part of the anterior transverse process, and is the same on both sides. It is separated from the process proper by an oblique suture, seen both before and behind, running downwards and outwards, dividing the wall of bone nearly equally, so that the rib is broad internally where it rests on the body, and tapers outwards to nearly as far as the end of the anterior process proper. Total length $\frac{5}{12}$ inch. As seen from below, it rests against the anterior half, as seen from above against the anterior third, of the body, the neural arch resting on the posterior part. Both rib and neural arch are seen to form the lateral part of the intervertebral "body" surface, above and below. The anterior transverse process proper is, like the posterior, ossified from the neural arch. It passes forwards and outwards behind and above the rib, and meets the posterior at the outer end of the well-marked foramen, at the fore part of the nerve-groove, a very little way external to the apex of the rib. Thus a foramen is completed by the two processes quite irrespective of the rib, although the back of the latter forms the lower part of the front wall of the foramen. A small additional foramen exists behind the normal foramen on the right side, no other vertebra of this neck shewing it. The 5th vertebra shows, and indeed the 4th, 3rd, and 2nd also show, on their under aspect, traces as if from fissure between the fore and back parts of the arch where it rests on the sides of the body, but these are not reliable.

On the *seventh* vertebra, the rib or additional element is differently placed, being farther out and not reaching in to touch the body of the vertebra. The neural arch rests against the whole side of the body, from before backwards, sending out a broad anterior process in front of the foramen to meet the posterior process, which has turned round far enough to form the outer end of the foramen and the outer half of the nerve-groove. The rib reaches outwards as far as the tip of the posterior transverse process, and, tapering inwards, ceases $\frac{1}{4}$ inch from the body proper, reaching as far in as opposite the inner end of the foramen. Total length of rib $\frac{5}{12}$ inch. The rib is broadest about its middle, forming two-thirds of the breadth of the compound anterior transverse process, and the suture which unites it to the two transverse processes is very irregular. This applies to the left side. On the right side, my notes, made in 1857, state that "a ligament completed the foramen. No separate bony element existed here." The ligament has perished, the broken points of its attachment remaining visible, opening up what has been a foramen about the same size as that on the left side.

Case 2. *Moveable Cervical Rib, developed to the extent of head neck and tubercle, on both sides, in a female subject aged 7 years.* Preparation of two lower cervical vertebrae and two upper dorsal vertebrae with their ribs. In contrast with the last case, these ribs form the entire anterior boundary of the foramen. They represent the head neck and tubercle of a rib, and pass about $\frac{1}{4}$ inch beyond the tip of the transverse process. They are nearly symmetrical, the left a little broader and more marked with a nerve-groove, the right passing a little farther beyond the tip of the transverse process. Total length $\frac{7}{12}$ to $\frac{8}{12}$ inch. A conical parapophysis, $\frac{1}{8}$ inch in length, rises from either side of the body, upon the end of which the obliquely cut head of the rib is movably articulated. The foramen, or space, which they bound is, on the left side, chiefly formed by a deep notch in the posterior process and is of moderate size, on the right side more shallow and smaller. Beyond this they are moveably articulated, for $\frac{1}{3}$ inch, to the posterior transverse process. Greatest breadth of rib here, right $\frac{2}{12}$, left $\frac{3}{12}$ inch. The sixth vertebra presents a normal lateral foramen on the left side, about twice as large as that of the 7th, but a very small one on the right, smaller than that of the 7th.

Case 3. *Similar to the last.* Preparation of a young spine, in section, about 20 inches in length. All the other vertebrae and ribs normal. Conical parapophysis $\frac{1}{8}$ inch long, against which head of rib is movably articulated. Neck of rib bounds a large foramen on both sides. Costo-transverse articulation for $\frac{1}{4}$ inch, and ribs project $\frac{1}{4}$ inch beyond tip of process. Ribs expand opposite and beyond their external articulation. Left rather the largest but nearly symmetrical. Total length $\frac{7}{12}$ to $\frac{8}{12}$ inch. Greatest breadth at outer end $\frac{3}{12}$. Neck and head are more flattened than in the last case.

Case 4. *Cervical Rib, to the extent of head neck and tubercle, free on right side, ankylosed on left. Position of arteries and nerves.* Adolescent subject, the body epiphyses not being united, and the tips of the spinous processes cartilaginous. Preparation now presents the cervical vertebrae with the first dorsal vertebra and its ribs. Cervical rib on right side to the extent of head, neck, and tubercle. Length nearly 1 inch. Rather more than the inner half is a narrow bar $\frac{1}{12}$ to $\frac{1}{8}$ inch broad; outer part suddenly enlarged to a breadth of $\frac{4}{12}$ where it rests on the posterior transverse process, presenting a triangular mass which tapers outwards to a distance of nearly half an inch beyond the transverse process. Rib was articulated at both its costo-vertebral and costo-transverse connections by cartilage, allowing of motion. Head rested on a parapophysis $\frac{1}{8}$ inch in length, flattened, and extended vertically at its root. Neck of rib shews a nerve-groove on which the 7th cervical nerve was seen to rest. Internal to this it becomes flattened, expanding at last, vertically, to a breadth of $\frac{1}{6}$ inch where it meets the parapophysis. On left side, rib completely ankylosed, leaving no kind of trace internally, nor any externally except that an undulation seems to mark off where the triangular tubercle has joined the posterior process. The tip of the now united mass does not reach so far outwards, by nearly $\frac{1}{4}$ inch, as the tip of the rib does on the right side. The bar in front of the foramen is more flattened at the nerve-groove than the neck of the rib on the right side is.

The right vertebral artery divided immediately at its origin, half an inch below the level of the 7th foramen; the posterior, rather the smaller, entered the 6th foramen, and the two re-united between the 6th and 5th foramina, the artery then having the usual course. The left vertebral artery arose normally and entered the 6th foramen. Arising behind it from the subclavian was a small artery, about $\frac{1}{4}$ its size, which entered the 7th foramen, but was lost between the 7th and 6th foramina. In the now macerated bones the left 7th foramen is oval and rather large, being 4 lines in its long diameter, and rather more capacious than the rounded 6th foramen above it. The foramen, or costo-vertebral space, on the right side is larger and elongated outwards into a narrow apex. The narrow outer part was occupied by fibrous tissue; the larger part was closed by a fibrous membrane, the naturally perforated part of which was under a line in diameter. The notches representing the additional foramina in this neck are noted under that section, case 3. The notch for the posterior foramen on the right side of the 6th vertebra is large, about $\frac{1}{2}$ to $\frac{1}{3}$ the size of the anterior foramen (through which the posterior division of the vertebral artery probably passed), which again is considerably less than that of the 5th through which the re-united vertebrals passed. The 6th foramen on the right side has the full size.

Case 5. *Cervical Rib, to the extent of head neck and tubercle,* *free on left side, ankylosed on right.* Female aged 40. Preparation of entire spine with 1st and 12th thoracic ribs. Length of cervical rib $1\frac{1}{4}$ inch. Projects over $\frac{1}{2}$ inch beyond transverse process. Head flattened and rests in a facet upon a short thick parapophysis projecting from upper part of side of body. Joint was surrounded by ligament and presented cartilaginous surfaces and a cavity. Costo-transverse joint $\frac{5}{8}$ to $\frac{6}{8}$ inch long, and when opened presented cartilaginous facet $\frac{4}{8}$ inch long, transversely, by $\frac{1}{8}$ broad. The facet was at the lower and outer part of the connexion, the rest being strong interosseous ligament. Nerve-groove double. Foramen a moderate-sized oval space internally, half the size of the right foramen, prolonged as a narrow fissure externally which an interosseous ligament occupied. Vertebral artery entered on right side at 6th, on left side at 4th. Left foramen of 6th undersized, of 5th small. On the right side the lines of union have disappeared; tip projects $\frac{1}{4}$ inch less than that of rib on other side. Nerve-groove single. First thoracic rib seems as if it had touched 7th vertebra, at least on right side, but there is no real notch. Other peculiarities of this preparation are,—12th thoracic ribs small, left the shortest. First coccygeal bone ankylosed to sacrum. Atlas has posterior bridge on both sides, (case 4 of that variety).

Case 6. *Cervical Rib, to the extent of head neck and tubercle, on left side, ankylosed externally on right.* Preparation of cervical vertebrae, adult and otherwise fully ossified except that the laminae of the atlas have not quite united behind. (Already referred to with case 3 of that variety.) On *right* side a fissure remains between head of rib and a well-marked flat tapering parapophysis, which projects from above the middle of the body. Head of rib here thin and $\frac{1}{10}$ inch in breadth. Is bulged forwards with large foramen. Moderate anterior tubercle, succeeded by broad and deep nerve-groove. Externally no reliable trace of ankylosis remains above, but line is distinctly seen on under surface. United mass tapers to a point outwards and forwards, 5 lines beyond transverse process. Foramen large and rounded with addition of a narrow part externally, the rounded part as large as that of the 6th, which is large on both sides. *Left side.* Rib now lost. Vertebra shews two smooth facets where the rib has articulated; one on the well-marked parapophysis, $\frac{1}{6}$ inch vertically by $\frac{1}{12}$ in breadth; the outer, on the anterior edge of the transverse process, $\frac{1}{4}$ inch in length by $\frac{1}{8}$ in height, facing forwards and outwards. The transverse process is a little shorter and more pointed than the part referable to the transverse process on the other side. The foramen has been about half of that of the right side, as indicated by the deep oval notch.

Case 7. *Two cases of Cervical Ribs, to the extent of head neck and tubercle, ankylosed on both sides.* (*a*). Adult female. The elongation and curved form of the transverse processes shew that cervical ribs have existed here prolonged for about half an inch beyond the transverse processes proper. Although there is no mark like a suture, one can readily see, by the undulation and the direction of the part beyond, where the union with the process has taken place. The tip of the left is 1 inch, measured straight, from the body of the vertebra, that of the right over $\frac{3}{4}$ inch, its tip being more curved in and more pointed than that of the left. They project beyond the tip of the posterior transverse process of the 6th, on the right side 3 lines, on the left side 5 lines. Anterior boundary of foramen straight and rather thick on left side. Nerve-groove well marked. Foramina oval; left about as capacious as the rounded foramen of the 6th above it; right somewhat larger with a point externally, and thrice the size of the foramen of the 6th above it, which is small, that of the 5th being full-sized. The 7th vertebra has on its right side what seems to be a true notch for the head of the first thoracic rib, not merely a mark for the ligament.

(*b*) Also from an adult female, and so closely resembling the last case as scarcely to require separate description. In this case the right is the longest, the tip fully 1 inch from the body, that of left $\frac{7}{8}$ inch. Projection beyond posterior transverse process of sixth, right side 6 lines, left side 4 lines. Foramen of left side oval and smaller than foramen in sixth; on right side elliptical and large, $\frac{3}{8}$ inch in length and over half of that in breadth at the middle. Anterior boundary of foramen more slender, and has better marked nerve-groove than on left side, and presents a small anterior tubercle.

Case 8. *Loss of Cervical Ribs causing apparent want of the foramen in the seventh vertebra.* The nature of such cases is evident, the rib having been lost in maceration the lateral foramen appears to be wanting. A good instance of this is seen in a full-grown male skeleton in the Anatomical Museum of the University. The facets for the head and tubercle of the missing cervical ribs are well marked on both sides. The smooth facet on the end of the short parapophysis is round and about $\frac{1}{8}$ inch in diameter on the left side, vertically oval on the right; the facet on the transverse process is rounded, concave, $\frac{1}{4}$ inch in diameter, and placed on the lower half of the outermost part of the front of the process, facing forwards and a little outwards. The outer edge of this facet is 1 inch from the body of the vertebra. One would infer from the size and completeness of the facet, and from the robustness of the transverse processes to their end, that the lost rib had been developed some way beyond the tubercle. Although the normal foramen is thus wanting, there is what might have been mistaken for it in a reduced condition, the notch of an additional foramen on both sides, that on the right side nearly completed into an oval foramen $\frac{1}{8}$ inch in its long diameter. This additional foramen is present, on the left side, also in the 6th and 5th, and on the right side in the 4th and 5th, in the latter as a deep notch. (This case is in addition to the 16 cases given under that variety.)

The various forms presented by the transverse process, or what is included in that term, of the 7th vertebra are understood by referring to the various degrees to which the normal cervical rib of early life may be developed before becoming ankylosed,—when it gets well in front of the outer end, increasing the process in breadth, antero-posteriorly; when it passes beyond it, increasing the length of the process and giving it a curvature forwards; and, it may be, increasing the robustness of the process proper, both antero-posteriorly and vertically, to give support and surface for articulation. The varying conditions also of the neck of the rib farther affect variously the size and form of the foramen, so that, in fact, it is not easy to get two seventh cervical vertebrae whose transverse processes are exactly the same[1].

[1] The seventh cervical vertebra is well known to vary much in different groups of the mammalia in regard to the presence or absence of the "perfora-

The preceding seven cases of cervical rib, occurring to the extent of what may be termed its vertebral or posterior stage, illustrate a condition which I believe is more common than appears to be generally supposed. From the situation of the part and the mode of proceeding in dissection, this particular region is apt to be left over and afterwards neglected. Were it looked for, I believe that these short cervical ribs in a non-ankylosed condition, or ankylosed after abnormal prolongation, would be more frequently found.

I have spoken of these cases as representing only the head neck and tubercle, the short stump projecting beyond the transverse process hardly deserving to be regarded as shaft. I now proceed with the cases in which the cervical rib was developed in its middle stage or shaft, or also in its anterior or sternal stage.

tion" in the transverse process. It was found by Professor Owen not to be present in the *Gorilla*, but in that of an adult male gorilla in my possession there is a large oval foramen on the right side, bounded in front by a slender bar of bone, in most of its length as narrow as a small-sized pin. On the left side the narrow part is wanting, apparently not broken, leaving a deep oval notch which would have formed a smaller foramen than that on the right side. On the right side at least, the foramen is larger than, though not so round as, the foramen in the 6th vertebra. The Atlas of this gorilla, I may mention, presents natural deficiency of most of the anterior transverse processes, especially on the left side. It is not usually present in the *Horse*, but in a horse in the Anatomical Museum of the University, the foramen is present on the right side and is fully as large and as rounded as that of the 6th vertebra, and bounded below by as thick a bony wall, fully ankylosed. The transverse process beyond is thickly bifurcated; the superior part prolonged backwards; the inferior projecting forwards, and also continued backwards on the body of the vertebra. The left side has neither foramen nor inferior process. In a specimen from a *Sheep*, which I picked up on the hills, the foramen is present. The preparation now before me, includes the 6th and 7th cervical vertebrae, and the 1st dorsal with its ribs. On the right side, the foramen is rounded and about half the size of the foramen of the 6th, and is bounded below by a strong completely ankylosed bony wall; on the left side it is bounded below by a narrow ligament, leaving an equally large but oval perforation. The body epiphyses of these vertebrae are not yet ankylosed, and an epiphysis is seen on the back part of the free edge of the inferior transverse process of the 6th, on the left side, this part on the right side having been destroyed. The foramen is not normally present in the *Elephant*, but in the skeleton of an adult Indian elephant in Dr Barclay's Museum, in the keeping of the Edinburgh College of Surgeons, from which I was in the habit of delivering my lectures on the osteology of the elephant, the foramen is present on the right side, the inferior boundary, however, not joining the body of the vertebra, a gap of ½ inch intervening. On the left side there is a deep notch. I have twice noticed in not full-grown elephants a well-marked notch corresponding to the back part of this foramen. In one of the two *Camels* in the Edinburgh College of Surgeons Museum (camelus dromedarius) the foramen is present on the right side, and I noticed it present on the right side in a camel (camelus dromedarius) in the excellent Anatomical Museum in the University of Jena. The variety occurring in the camel is of further interest, considering the position of the foramen, or canal, in the five middle vertebrae of the neck in that family.

Case 9. *Cervical Rib developing a shaft and resting by its anterior end on a conical process of the first thoracic rib. Recognised by me during life.* The cervical rib and the first thoracic rib were removed at the post-mortem examination. From a young woman, left side. As to the right side I can only now say that I do not recollect that there was any thing there to attract attention. The *first thoracic rib* is well formed, measures $4\frac{1}{4}$ inches along the outer edge, 3 inches straight from end to end, at the furthest points, and $\frac{5}{8}$ in breadth before and behind the base of the conical process; and it has a good cartilage at its sternal end. *Cervical rib.* Total length $2\frac{1}{2}$ inches, of which $1\frac{1}{2}$ belong to the shaft. Presents head, neck, and tubercle fully as distinctly formed as those of the first thoracic rib, the neck broader and thinner, and the tubercle more projecting owing to the narrowness of the shaft. Shaft narrower than neck but more rounded; breadth of shaft $\frac{1}{5}$ inch, thickness $\frac{1}{6}$. An elevation about the middle of the upper surface marks off two grooves, each as broad as the little finger, the anterior best marked, and here I infer that the subclavian artery lay. In front of this groove the rib forms a rounded button-like terminal expansion, $\frac{3}{8}$ inch in diameter, $\frac{2}{8}$ in thickness. The shelving outer half of this expansion articulates moveably with the blunt apex of the conical process, having the appearance as if there had been a cavity surrounded by a strong capsular ligament, the latter, however, deficient on the pleural aspect. The two ribs are over half-an-inch apart. *Conical process* on first thoracic rib, length $\frac{1}{2}$ inch; breadth at blunt apex $\frac{3}{8}$, at its expanded base about $\frac{3}{4}$, but limit not very definite as the anterior border runs very obliquely into the inner border of the rib. The cone is thick and triangular, inner surface rising from the inner border of the rib, the edge between the anterior and posterior surfaces reaching some way on the upper surface of the rib. The process is situated two inches in front of the tubercle, and $1\frac{1}{4}$ inch from the anterior end of the bony rib.

Case 10. *Cervical Rib on both sides; on right side, shaft resting by its anterior end on conical process of first thoracic rib; on left side, shaft prolonged to sternal connection.* Female aged 65.

Vertebrae normal throughout, except that 7th carries the cervical ribs. Besides, there are the twelve thoracic ribs, the 12th pair about 3 inches in length. The three last coccygeal bones united, the first moveable. *Ribs and their anterior connections.* The cervical rib on the *right side,* the shorter of the two, has a close resemblance to the cervical rib in the case last noticed. Length of head neck and tubercle, $1\frac{1}{8}$ inch. Shaft also $1\frac{1}{8}$, and very like another head and neck turned forwards, nearly at right angles, but more rounded in form. Neck at middle $\frac{1}{4}$ inch broad, $\frac{1}{10}$ thick; shaft at middle $\frac{1}{4}$ broad, $\frac{1}{5}$ thick. Breadth of rib at its tubercle $\frac{1}{2}$ inch. Shaft on upper surface is on the whole convex, bending down to meet the conical process; a groove in front of tubercle corresponds to position of 1st dorsal and 8th cervical nerves, and there is a very shallow groove at the fore part. Anterior end enlarges a little, to 5 lines in breadth and 4 lines in thickness, and rests abruptly against hinder aspect of top of conical process of first thoracic rib. The joint between them presents a strong capsular ligament, but nearly wanting on the pleural aspect. End of rib notched, partially embracing top of conical process, part on sternal side but most rests on the flat facet of the process which looks upwards and backwards. Upward and downward motion free. Synovial cavity present and both surfaces smoothly cartilaginous. Upper $\frac{1}{3}$ of conical process composed of cartilage. Length of process at middle $\frac{1}{2}$ inch, more on sternal side, less behind. Breadth at middle 5 to 6 lines, at top 4 to 5 lines, at base about $\frac{3}{4}$ inch but not exactly defined. Thickness, in all its length, nearly 4 lines. Pleural surface flat, rising from the rounded-off inner border of the rib, outer surface convex. First thoracic rib,—breadth in front of conical process 8 lines, behind it 5 lines. Length of head neck and tubercle $1\frac{1}{4}$ inch; of shaft along outer edge $3\frac{1}{2}$, along middle $3\frac{1}{4}$. Length of costal cartilage, upper margin 1 inch, lower margin $1\frac{1}{2}$. Breadth at middle 7 lines.

Left side. Cervical rib; length of head neck and tubercle $1\frac{1}{8}$ inch. Length of shaft 2 inches. Thinner than right, breadth at middle over $\frac{1}{4}$ inch, thickness $\frac{1}{8}$. The anterior groove, where the subclavian artery lay, is well marked, its middle is $1\frac{1}{4}$ inch in front of hinder edge of tubercle. This groove is deepened in front by the development of a scalene process, in the form of a low triangular elevation from inner margin of rib, to which the anterior scalene muscle is attached. Breadth of rib at this process, ½ inch. At the front of this process, but ¼ inch further at the lower edge, the rib ceases to be bony, and is prolonged as cartilage, 1¼ inch in length, ¼ in breadth, till it reaches and blends with the upper part of the cartilage of the 1st thoracic rib. There is a break in this narrow cartilage, ½ inch from the anterior end of the rib, which shews a kind of cavity when cut into, but, although it is very like a joint, I will not aver that it is not a fracture. First thoracic rib.—Head neck and tubercle 1¼ inch. Length of shaft 4½ inches along outer edge, 4 along middle. Breadth towards back 6 lines, increasing forwards to 8 lines. Length of cartilage of this rib, at lower margin 1½ inch, at upper part before it unites with the cartilage of the cervical rib, ½ inch; length of united cartilage ¾ inch. Breadth of united cartilage at the middle ¾ inch, thickness ⅕.

Connection with the vertebrae. Costo-vertebral joint. The two cervical ribs rest entirely on the 7th vertebra. The left had a capsular ligament allowing free gliding motion. Within this a synovial cavity with not very smooth cartilaginous surfaces. Shelving head rested obliquely on front and end of a short parapophysis. On right side, an oblique ligament passed from the head to the fibro-cartilage above; a strong ligament, ¼ inch thick, passed down to the head of the first thoracic rib, preventing the two heads from being separated farther than ¼ inch; and between these a capsular ligament bound the convex head into a socket which lies very close to the socket for the head of the rib below. The first thoracic ribs rest in part on the 7th cervical vertebra by rounded heads, and had a stellate ligament, but I saw no inter-articular ligament. Synovial capsule present and rather spongy cartilaginous surfaces. The costo-transverse articulation on both sides presented synovial cavity and smooth cartilaginous surfaces, transversely oval and ⅓ inch in length; above the facet a transverse fissure into which a ridge of the rib fitted; and strong ligamentous fibres existed externally all round. Tips of transverse processes still covered with cartilage.

Muscles connected with the cervical ribs. On the right side only the external *intercostal* muscle was present, the space 1 inch in length, $\frac{1}{3}$ inch in height. On the left side, the space $3\frac{1}{2}$ inches in length by under $\frac{1}{2}$ inch in height; the internal intercostal also was well developed, with the usual absence of the internal at the back part and of the external at the fore part. The *scalenus anticus* was, on the left side, attached to the process above noted on the cervical rib, having the subclavian artery behind it. On the right side the muscle had been torn, the remains of its insertion being on the end of the cervical rib and on the conical process of the first thoracic rib. This process, occurring so often in cases of cervical rib extending only to this extent, may be looked on as the normal scalene tubercle, or process, of the first thoracic rib in a more developed condition. The muscle having been torn through, and the subclavian artery displaced, I could only infer that on this side also the artery lay behind the scalenus, but there is only a very shallow groove on the rib here. The *scalenus medius* was attached partly to the first thoracic rib, partly, about half of it, to the cervical rib, the insertion beginning just in front of the tubercle and extending for $\frac{3}{4}$ inch outwards on the shaft. The part of the scalenus medius which comes from the 6th transverse process was detached as a separate muscle, forming a *levator costae* to the cervical rib. It was about the size of an ordinary levator costae muscle, larger on the left than on the right side. Arising from the lower edge of the posterior transverse process, it passed downwards expanding to be inserted into the cervical rib at the outer part of the neck and extending to beyond the tubercle. The back part of it, separating from the rest, was inserted into the 7th transverse process, representing a *posterior inter-transverse muscle.* The anterior *inter-transverse muscle* was a small and flattened but very distinct bundle, $\frac{5}{8}$ inch in length, $\frac{1}{8}$ in breadth, arising from the lower edge of the anterior process, inserted into the fore part of the upper surface of the neck of the cervical rib, nearer the tubercle than the head. The 7th nerve passed out between this muscle in front and the cervical levator costae and posterior inter-transverse muscle behind. A muscle appearing as a levator costae to the first thoracic rib arose partly from the 7th transverse process but mostly from the cervical rib external to the tubercle, concealing the back part of the external intercostal proper. The only other muscle attached to the cervical rib was, to its tubercle, the ascending tendon of one of the long muscles of the back, its lower connections not seen.

The right *vertebral artery* arose from the subclavian opposite the mammary, an inch from the bifurcation of the innominate, and entered at the 6th foramen; the left arose from the arch of the aorta between the left carotid and subclavian, and after a course of four or five inches entered the foramen of the 5th vertebra. It is of good size though somewhat less than the right. The deep cervical artery, on both sides, passed back between the cervical rib and the first thoracic rib. The 8th cervical and 1st dorsal *nerves* passed across the upper surface of the cervical rib, uniting on it, and resting on a shallow groove on the inner side of the back part of the shaft, the 7th nerve passing obliquely across the front of the neck.

(i) RECOGNITION OF CERVICAL RIB IN THE LIVING BODY. SURGICAL AND HEREDITARY ASPECTS. When a cervical rib is developed some way beyond the vertebra it assumes a surgical importance. The projection may be mistaken for a morbid growth, and the pulsation of the elevated artery might at first be taken for a commencing aneurism. The late Professor Syme was familiar with the condition, under the name of exostosis of the first rib, and I remember his mentioning to me in 1853 the case of a medical man who had come to consult him in great alarm under the impression that he had discovered an aneurism of his subclavian artery.

1. The case No. 9, above related, occurred to me when I was surgeon to the Edinburgh Infirmary. The patient was under treatment for some internal complaint when I was asked to see her on account of the tumour at the bottom of the neck, and I had no difficulty in recognising the nature of the case. There is no reason why this variety should not, like other varieties be hereditary, and as the condition admits of being recognised in the living body, the question of its hereditary transmission admits of being determined. For the following two cases in which the cervical rib was recognised during life

by them, I am indebted to the gentlemen whose names are mentioned.

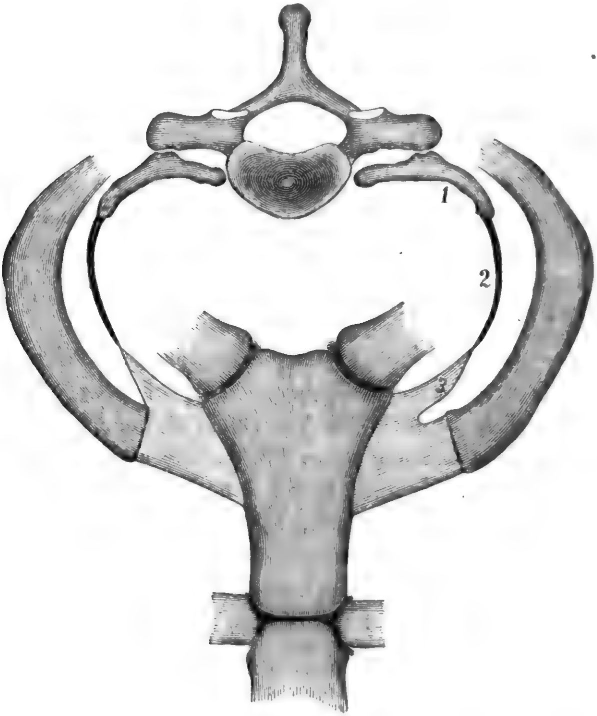
2. *Case in which a Cervical Rib was recognised in the living body by Mr Wilkes, of Salisbury, reported to me by him.* E. H., a woman aged 56, admitted to the Salisbury Infirmary, August 1874, under Mr Wilkes' care, suffering from chronic disease of the right shoulder-joint. She is very thin, rendering the parts distinct. Mr Wilkes noticed a very *prominent knob* in the middle of the *left* posterior triangle, and recognised it to be a cervical rib, an opinion in which his colleagues concur. The prominence ends as a knob of bone, the size of the last division of an adult man's thumb; projects boldly outwards and forwards, and from the under surface of the knob a hard continuation can be traced to a part beneath, apparently the first rib. Distance of knob from spine of 7th cervical vertebra, $4\frac{1}{2}$ inches; from middle line of neck in front, 3 inches; from centre of clavicle, arm natural, 2 inches; when arm is raised, 1 inch; from the knob to the left sterno-clavicular articulation, $3\frac{1}{4}$ inches; to the end of the acromion 5 inches.

The *subclavian artery* seems raised quite two inches above the clavicle, and is most dangerously situated for injury. In its third stage, traced upwards and inwards from the middle of the clavicle to the knob, the artery is seen pulsating, as if subcutaneous, and might easily be mistaken for an aneurismal dilatation. Above and external and somewhat posterior to it are felt the cords of the brachial plexus of nerves. In the situation of the knob the pulsation is lost, leaving the position of the artery here uncertain. To the inner side of the scalenus anticus, is felt the connecting bond between the cervical rib and the first thoracic rib, and then the first stage of the artery, outward pressure on which stops the circulation in the third stage and also the radial pulse. The external jugular vein passes downwards and inwards across the middle of the front of the prominence. In the *right* posterior triangle, on this side, as on the other, on a level with the 7th cervical vertebra, there is a similar prominence, much less developed, but enough to produce a more than usual fulness at this part of the neck. The artery is more deeply seated and as if smaller on this side, and elevated above the clavicle about an inch and a half. The patient has had the prominence as long as she can remember and has never had pain in it. Mr Wilkes has most kindly also sent me photographs of the neck, which shew quite plainly a conical projection on the left side in the situation described by him. He considers the state of parts to be similar to that presented by the specimen in my case No. 9.

3. *Case in which a Cervical Rib was recognised in the living body, by Dr Housley, of Lincoln, reported to me by him.* B. W., a man aged 25. In February 1873, when examining this patient's chest, Dr Housley noticed an unusual appearance on the right side of the neck, and on farther examination recognised it to be a case of cervical rib. The right subclavian artery is higher than the left when the clavicles are on the same level, and the pulsations are distinctly visible on the right but not on the left side. A cervical rib cannot be detected on the left side. The man has brothers and sisters who reside at a distance, but Dr Housley has most kindly examined those of the relatives who are within his reach—the mother, his children, one brother and his children—but found no trace of cervical rib in any of them. I expect however that it will fall to some one before long to meet with a case of hereditary transmission of this condition.

(B) Variations in the Thoracic Region.

(a) Imperfect condition of First pair of Ribs. Male subject aged 24. This case occurred in 1852, and the accompanying drawing of it is that which I published in 1853. There is no absolute certainty that it was not a case of supernumerary cervical rib. It was noted that it was carefully ascertained that there were only eleven other pairs of ribs, but it is possible enough that the presence of a rib on the 7th cervical vertebra may be accompanied by the absence of one on the 12th dorsal. It is also noted that the anatomy of the scalene muscles and subclavian vessels was normal, but this is not altogether incompatible with the supernumerary view. The general appearance of the supporting vertebra suggests a first dorsal rather than a 7th cervical, but the ordinary differences between these two vertebrae when normal, are just those which one would expect to be affected by the occurrence of one or other of the two



1. Rudimentary rib. 2. Ligament.
3. Small cartilage becoming blended with cartilage of next rib.

varieties—viz. the size and direction of the transverse processes, the form of the body and the somewhat variable length of its lateral elevations, the costal facets, and the slight differences between their upper and lower articular processes. The relation of the cartilages to the manubrium seems to favour the supernumerary view, but that also will be seen below to be compatible with either view[1]. The head had been removed, and

[1] By the kindness of Prof. Rokitanski I was enabled to make a note of a specimen of imperfect development of the first thoracic ribs, in the Pathological Museum of Vienna, which throws some light on this point. The whole of the cervical vertebrae being present there is no doubt as to the case being

[See description of similar case on subsequent pages of this number of the Journal.]

there is at least no record as to the lumbar vertebrae. I was perhaps more easily satisfied then than now, but with the question before me when the dissection was under observation, I was led to conclude that the case is one of imperfect first thoracic rib. With such doubts, the question occurs whether some of the cases which it has been customary to regard as instances of supernumerary rib, but in which the whole neck vertebrae were not examined, may not have been cases of imperfectly developed first thoracic rib. It is possible that case No. 9 of cervical rib, above described, may have been of that nature, but the appearances during life, and the resemblance to other cases, seemed to entitle it to be regarded as a case of cervical rib[1].

Note of the parts in this case. See also the woodcut. Head of each *rib* articulates with upper part of body of vertebra, lower part of body receiving as much of head of 2nd rib as body of vertebra below it does. Each has a good costo-transverse articulation. Length of head neck and tubercle 1 inch; length of shaft, right 1 inch, left 1¼. Left shews near its slightly expanded end a well-marked groove where the subclavian artery lay, best marked on the inner side; right shows groove on inner side but less marked, and very slightly marked

one of imperfect first rib. (No. 2882.) On left side, rib goes about ⅔ round, and articulates with a process of the second rib. On right side, it joins second rib at from ½ to 1 inch beyond tubercle, but again projects as a curved process where the subclavian artery has passed over it. The manubrium sterni first receives a broad cartilage, as if from one rib only, and, secondly, a cartilage at the junction of the manubrium and body, which is the cartilage of the *third* thoracic rib.

[1] *Case of imperfect first thoracic rib in a three-toed Sloth.* In a three-toed sloth (Bradypus tridactylus) in my possession, the first thoracic rib is very incompletely formed on one side. The *ninth* cervical vertebra shows, on the left side, its square-shaped rib, ¼ inch in length, resting abruptly on the transverse process; on the right side, it is ankylosed, the line of ankylosis barely recognisable; and there is no inferior transverse process or foramen. The *eighth*, besides the foramen, has the well-bifurcated transverse process; and, on the right side, the end of the blunt superior transverse process looks as if it had supported a rib, while that of the left side is flattened and tapers to a point. The *first thoracic rib* is complete on the left side, with its double implantation on the 10th vertebra, and meeting in front, but not ankylosed to, the lateral process of the presternum. On the right side this rib begins by head and tubercle attachments, but its shaft is only half an inch in length and terminates, in the macerated bone, by an irregular blunt end; thus presenting an approach to what might be called a 3rd cervical rib and a 10th cervical vertebra. The rather deficient right lateral process of the presternum ends in a short tapering cartilage, which terminates on and adheres to the second thoracic rib near its anterior end. The wanting two-thirds of the shaft may have been represented by cartilage and ligament.

on upper aspect. Breadth of each at the tubercle 5 lines, of shaft at middle 3 lines, thickness 2 lines, but left rib the largest all along. A *ligament*, narrow but strong, 2 inches in length, passes forward from the tip of each rib and joins the pointed hinder end of a narrow cartilage. This *cartilage*, 1 inch in length, $\frac{1}{4}$ inch in breadth, joins the upper part of the manubrium, and by its lower edge is in contact and apparently fused with the cartilage of the second rib, earlier on the right than on the left side. *Second pair of ribs*. Length of shaft 6 inches along middle, along outer edge $6\frac{3}{4}$. Average breadth 8 lines. Rough mark for serratus magnus muscle well developed, breadth here 10 lines. This gives a length of shaft 1 to $1\frac{1}{2}$ inches less than that of 2nd rib in four male specimens before me, and about 2 inches more than that of the first rib in the same skeletons. Transverse diameter of thorax between edges of 2nd ribs, almost 6 inches. Same of the other specimens, $6\frac{3}{4}$. Superior aperture of thorax, as bounded laterally by the rudimentary ribs and their prolongations, transverse diameter $4\frac{1}{2}$ inches, antero-posterior $2\frac{1}{4}$, which is fully equal to that of an average male thoracic inlet.

The *manubrium sterni*, as marked off by the non-union opposite the cartilage of the third rib, is longer than usual, 3 inches in length, while the body is shorter than usual, $3\frac{1}{4}$ inches, the more usual proportions being 2 to $2\frac{1}{2}$ and about 4. From the 3rd cartilage downwards the pieces of the body of the sternum are quite united, and receive the next four cartilages in the usual way. Cartilage of the 8th rib runs to the ossifying appendix, $\frac{1}{4}$ inch below the sternum. The increased length of the manubrium is not gained between the 3rd and 2nd cartilages, but opposite the broad united cartilage of the first two ribs, this cartilage being $1\frac{1}{2}$ inches in breadth, obliquely, along the line of its union with the sternum. The whole of this cartilage has an oblique slope downwards and inwards to the sternum[1].

[1] Although the Vienna specimen, above alluded to, shews that along with an undoubtedly imperfect first thoracic rib, the cartilage which meets the sternum at the junction of the manubrium and body may be that of the third thoracic rib, there are not wanting indications here that the first segment of the body has been ossified to the manubrium proper, which would explain the fact of the body supporting a cartilage too few and the manubrium one too many. Although it is not well shewn in the drawing, the edge of the sternum is not

Vertebra supporting the ribs. On examining a series of skeletons from behind and sideways, it is seen that the transverse processes of the 7th vertebra are more or less flattened, and are directed a little forwards and also a little downwards, the latter increased in appearance by the slope of the upper margin. In contrast with this, it is seen that the transverse processes of the 1st dorsal vertebra are directed backwards and also upwards, and are thick to their ends, and that their tips are wider apart than those of the 7th or 9th vertebrae. But these characters, in so far as they differ from those of the 7th, are adaptations to the support of ribs, and may be expected to vary accordingly. In the case under notice, the transverse processes of the vertebra supporting the rudimentary ribs are $\frac{1}{2}$ inch wider apart than those of the vertebra below, and are thick to their ends, but they are directed a little downwards and also a little forwards, while those of the vertebra below are directed much upwards and also backwards.

Muscles and arteries. The intercostal spaces were occupied in the usual way by the intercostal muscles and membrane. The scalenus anticus was attached, on each side, chiefly to the end of the rudimentary rib, partly to the ligament close to it, and a large tendinous slip passed down on the inside of the internal intercostal muscle to be fixed to the upper margin of the 2nd rib, which shews a slight roughness there. The subclavian vessels were normal in their relative anatomy. The artery lay immediately behind the scalenus upon the groove of the rib. As a line between the tips of the rudimentary ribs passes only $\frac{1}{8}$ inch in front of the body of the vertebra, the position of the subclavian artery must have been farther back than usual. A line drawn across between the subclavian grooves, at their

uniformly oblique, especially on the left side, but there is, first, a more outstanding part opposite the small first cartilage and part of that of the second rib, and below this, opposite most of the cartilage of the second rib, there is a notch similar to those which receive the cartilages on the body of the sternum. Opposite the lower part of this notch a faint elevation crosses the front of the sternum, smooth but quite as distinct as those between the notches for the 4th and 5th pairs of cartilages. On this supposition, the manubrium, in this case, would correspond exactly to the manubrium together with the first segment of the body of a robust sternum in my collection, in which the short manubrium is 1$\frac{3}{8}$ inch, the first segment of the body 1$\frac{1}{4}$, the division between them running across at the lower edge of the second cartilage, and there is almost no interval, on one side, between the outstanding part for the first catilage and the oblique part for the second.

fore part, gives a rather variable distance in front of the bodies of the vertebrae in different skeletons, ½ to ¾ inch, or even 1 inch.

(b) VARIETIES OF THE STERNAL END OF THE RIBS; GREAT BREADTH AND BIFURCATION OF RIBS, BIFURCATION OF CARTILAGES, ENCLOSED SPACES. I have several specimens of these varieties, which may be of interest to the physician or to the surgeon.

1. *Fourth rib on both sides becoming broad, and bifurcated in front.* Male aged 93. From about the middle of the shaft these ribs begin gradually to increase in breadth from 7 lines to 1½ inch on the left side, 1¼ on the right. They then fork, the left 1¼ inch, the right ¼ inch from where they join their cartilages. Cartilage of right forks close to rib, enclosing a space which admits little finger. Cartilage or cartilages of left now lost, but the diverging bony divisions, each of good breadth for a rib (6 to 7 lines) enclose an intercostal space 1½ inch in length, attaining a breadth of ¾ inch, which was probably continued forwards by the divisions of the cartilage or by two cartilages. This condition might well give rise to mistake in indicating the position of a chest symptom or of a fracture. The cartilage of the 7th rib on the left side is double for 1½ inch, nearer the costal than the sternal end, the two portions, each about half an inch broad, separated only by a narrow space. All the other ribs and cartilages on this side, and all but the 4th on the right side, normal. The cartilages are becoming invested by plates of ossification.

2. *Left fourth rib becoming very broad, and bifurcated in front; two large spaces, one in the bone, one at the bifurcation.* The other ribs normal in form, and number of ribs normal. Age and sex unknown, but rib is robust. Rib before it begins to enlarge, behind middle, 8 lines in breadth, at beginning of fork 1½ inch. Before it forks there is an oval window, length 8 lines, height 4, admitting point of fore-finger; edges of this window thin and irregular, but rib between it and the fork, which occurs 8 lines farther on, is of the full thickness. The large oval window is 1 inch in length by 8 lines in height; ¾ of it between the bifurcated bone, the rest between the bifurcated and now ossifying costal cartilage.

3. *Left fourth rib becoming broad towards sternal end, where it joins bifurcated cartilage.* Female aged 19. Same subject as case No. 1 of rudimentary 12th rib. Breadth of rib at middle of shaft 7 lines, at front end 14 lines. Vertically oval window between end and bifurcated cartilage 6 lines by 3.

4. *Rib broad at sternal end, with bifurcated cartilage.* Robust right rib, closely resembling 4th rib of case 1, but an inch longer. Over 12 inches in length, and is probably the 4th or 5th rib. Breadth at middle of shaft 8 lines; at front end 16 lines. Window between end and bifurcated cartilage admits point of fore-finger.

5. *Bifurcated cartilage.* Anterior $\frac{2}{3}$ of a robust left rib. Curvature indicates it to be probably the 4th rib. Rib broader than usual in anterior two inches, but rather diminishes in breadth along upper margin in last inch, and along here is applied the upper division of a bifurcated cartilage, the other division, the larger, meeting the end of the rib. Window admits point of fore-finger.

In three of these cases the variety was ascertained to be of the 4th rib, another probably of the 4th, the other two probably either of the 4th or 5th. In three it occurs on the left side only, in one on the right, in one on both sides. One was in a female aged 19. There is no trace of fracture or injury on any of these specimens.

(c) Variation of the Costal Facets on the 9th and 10th Dorsal Vertebrae. The text-books of anatomy differ in regard to these facets. The following is the result of the examination of 21 sets of vertebrae, excluding those which present other variations. The points to be noticed are, whether the 9th presents an articular facet on its lower edge for the head of the 10th rib, and if not, whether the facet on the 10th is complete. Also whether the costo-transverse facet of the 10th vertebra is absent.

The ninth vertebra had the lower facet on the "body," on both sides in 3; on one side, but uncertain whether present on the other side, in 3 (2 right, 1 left); on one side only in 4 (3 right, 1 left). Uncertain on both sides 2; leaving 9, perhaps 11, of the 21 in which the ninth vertebra bears no facet below.

Among these 9 cases the body-facet on the 10th had the appearance of being "entire" in 5. Thus in 17 of the 21, the facet on the tenth was not complete, at least the fibro-cartilage being necessary to its completion; and in 10 of the 21, the ninth vertebra had a lower body-facet in at least 3 on both sides, and in 7 others certainly on one side. I do not here include those in which the lower edge of the 9th vertebra presents not only the usual slight elevation to which the upper band of the stellate ligament is attached, but also a triangular recess below and behind the elevation. That recess, although it may accommodate the head of the 10th rib in certain motions, is not articular in relation to the rib, in the sense in which the other demi-facets are. The prominence and recess behind it are seen on the 11th and 12th and upper lumbar vertebrae. The lower part-facet on the 9th is large in some, in others small but distinct. The head of the 10th rib generally presents a corresponding modification, having a somewhat rounded outline above, the upper angle being more or less rounded off. These observations refer to the characters presented by the bones.

In the above 21 sets of vertebrae, the *costo-transverse facet* of the 10th dorsal vertebra was wanting, on both sides in 4, on one side (1 right, 1 left) in 2; and its presence was uncertain in one case on one side, in another on both sides. In only one case the absence of the 10th costo-transverse facets was conjoined with the presence, though uncertain on one side, of the lower facet on the body of the 9th; in all the other cases of absence of the 10th transverse facet, the head of the rib was set low, in two of them the body-facet on the 10th being entire. The absence of the transverse facet is in some accompanied by the absence of the tubercle of the rib; in others the tubercle is moderately developed[1].

[1] *Among the cases presenting other variations*, the following was noted of these costal facets. In two cases of unequal 12th ribs (cases Nos. 3 and 4) the head of the 10th rib had an entire facet on the 10th vertebra; in one, the costo-transverse facet was wanting on both sides, in the other it was present on both sides. In case No. 8, lumbar variation (dorso-lumbar vertebra less than usual, and movable 12th rib on one side only), the head of the 10th rib did not touch the 9th vertebra and the 10th costo-transverse facets were wanting. In the five cases of additional dorso-lumbar vertebra (cases Nos. 3, 4, 5, 6, 7 lumbar variation) in all the head of the 10th rib articulated in part with the 9th vertebra, except on one side in case No. 6. In case No. 3 (13th pair of ribs also present) the costo-transverse facet was wanting on both sides

The costal facets on the 9th and 10th dorsal vertebrae, therefore, vary so much that they cannot be relied on as distinguishing characters of these vertebrae. If the 9th has the part-facet below, it resembles the 8th; if that facet is wanting, it resembles the 10th. Unless the 10th has the body-facet entire, it cannot be distinguished from a 9th; and as, along with an entire body-facet, it may want the transverse facet, it comes in these respects to resemble an 11th. In like manner the 11th resembles the last-mentioned variety of the 10th, or it may have the lower articular processes turned outwards, and be taken for a 12th. Again, the 12th may not have its lower articular processes turned outwards; and the 1st lumbar may have carried a rib. These varieties, however, of the two last dorsal and of the 1st lumbar are rare, compared with those of the 9th and 10th dorsal.

(d) IMPERFECT DEVELOPMENT OF 12TH RIB. Case 1. *Twelfth Ribs very small.* Female aged 19. Preparation of three dorsal vertebrae and first lumbar, with 11th and 12th ribs. Twelfth pair of ribs so small that they might easily have been overlooked. I ascertained carefully that these were the twelfth from above downwards, and there were five lumbar vertebrae below them. They are nearly symmetrical. Length of right 1 inch, of left a line less. Breadth at the middle, right $\frac{1}{8}$ inch, left $\frac{1}{6}$, each expanding a little at the end. Thickness of outer half under a line, of inner half nearly $\frac{1}{8}$ inch. Head rounded, and $\frac{1}{4}$ inch from it is a tubercle, where the rib also bends forwards, giving the appearance of a neck and tubercle. Head retained by capsular ligament, articulates with a facet on the upper and fore part of the pedicle near where it joins the body, and corresponding to where head of 11th rib joins its vertebra, although the 12th rib appears as if not so far back on the pedicle owing to its lesser size. Change of direction of articular processes takes place between 11th and 12th dorsal vertebrae. This modifies the character of the neighbourhood of the superior articular process of the 12th vertebra; metapophysis (superior tubercle, or mammillary process) moderately de-

on the 10th, but present on one side of the 11th vertebra. In case No. 4 (13th pair of ribs also present) the 10th costo-transverse facet was absent on one side, well marked on the other side.

veloped; anapophysis (inferior tubercle, or accessory process) very slight; no transverse process (external tubercle) present. Transverse process of 1st lumbar 5 lines in length, 3 in breadth, and springs as usual from the back part of the pedicle, with a slight anapophysis behind it. *Eleventh* ribs each 6 inches in length, and $\frac{1}{2}$ inch in breadth at middle, where they are broadest. Besides costo-vertebral articulation, they are connected to the external tubercle by a strong ligament. This case was published in 1853 along with the case of imperfect 1st thoracic rib above noted. It is one of the cases (No. 3 of that variety) in which the sternal end of the left 4th rib was broad, with bifurcated cartilage.

Case 2. *Same as the case just related.* Adolescent subject. Preparation shewing 7th cervical vertebra, 12 dorsal vertebrae with their ribs, and 3 lumbar vertebrae; a vascular preparation. Eleventh ribs 4 inches long, $4\frac{1}{2}$ with the cartilage. Rudimentary 12th rib, length of left 1 inch, of right $\frac{3}{4}$; breadth of each about $\frac{1}{8}$ inch. Inner end is set on anterior and upper part of pedicle of vertebra, the right by a short intervening process, corresponding to where the 11th rib is set upon its vertebra. Change of direction of articular processes of vertebrae takes place chiefly between 11th and 12th dorsal.

Case 3. *Twelfth Ribs short and unequal.* Female aged 40. Vertebrae, C. 7 (with rib on 7th; case No. 5 of cervical rib), D. 12, L. 5, S. 6, C. 3. Length of left 12th rib $1\frac{1}{6}$ inch, of right $1\frac{3}{4}$. Breadth of left 3 to 4 lines, right the same but much larger than left at its head. Head of right articulated on short blunt elevation on lower $\frac{2}{3}$ of side of pedicle, corresponding to where 11th rib rests on its vertebra, making allowance for the elevation pushing back the articulation of the 12th. A low tubercle or roughness external to the head, but without any interval, is in contact with a slightly developed transverse tubercle of the vertebra, but there is no facet. The fusion of the rib and vertebra would, at this part, represent the transverse process of the first lumbar vertebra. The shorter rib (left) rests on a narrow eminence below the middle of the pedicle, by a notched head, the part behind the notch not quite close to the slightly developed transverse tubercle behind it. Change of direction of articular process has taken place partially between 11th and 12th vertebrae on left side, being the side of the smaller 12th rib. Tenth dorsal vertebra has an entire costo-capitular facet and a very large costo-transverse facet, although the transverse processes are short.

Case 4. *Very unequal 12th Ribs.* Male aged 47. Vertebrae, C. 7, D. 12, L. 5, S. 5, C. 4. Twelfth ribs of very unequal length, that of left 3½ inches, of right scarcely 2 inches. The larger one has a much larger and more distinct head, and a broader shaft than the other. The three tubercles on the transverse process of the 12th dorsal vertebra are very pronounced on both sides. The external of these is in series with the transverse processes of the lumbar vertebrae, but, as far as mere position and form go, if the transverse processes are looked at from above, the antero-posterior broadening at the root suggests a double relation, very distinct in this specimen, the posterior continuation corresponding to the external (transverse) tubercle of the 12th dorsal vertebra, the anterior to the 12th thoracic rib, this root of the process curving forwards on the pedicle. The head of the lesser (right) 12th rib is flat, rests on the upper half of the body of the vertebra, at the fore part of the pedicle, on a slight elevation. Behind, it has a cartilaginous facet on its lower part, an interosseous ligament at its upper part. The upper band of the stellate ligament went to the fibro-cartilage above. A strong costo-transverse ligament connected the rib to the external of the three tubercles on the transverse process, leaving a costo-vertebral space, or lateral foramen, between the two articulations. In connection with the shortness of the 12th rib on the right side may be noted the fact, that the transverse process of the 5th lumbar vertebra is ankylosed to the sacrum on that side. The 10th dorsal vertebra has an entire costo-capitular facet, and no costo-transverse facet although the transverse processes are well developed.

Case 5. *Twelfth Ribs short and ankylosed to Vertebra.* Female aged 62. Considerable lateral curvature of spine to left side, with articulation of left transverse process of 5th lumbar vertebra to sacrum. Vertebrae, C. 7, D. 12, L. 5, S. 5, C. united and obscure. All the other ribs normal. Length of eleventh

$5\frac{1}{2}$ inches. Twelfth ribs, right $1\frac{3}{8}$, left $1\frac{2}{8}$, breadth about $\frac{1}{4}$ inch. Left thick internally, tapering outwards, with a direction downwards (this being the side to which the spine is curved), and passing $\frac{1}{2}$ inch farther out than the transverse process of the 1st lumbar vertebra. Right directed rather upwards and nearly parallel to the lumbar transverse process, and passing over $\frac{1}{2}$ inch beyond it. Line of ankylosis quite visible on right side, just traceable on left. The heads have been implanted on short processes from the fore part of the pedicle, corresponding to where the 11th ribs rest on their vertebra. On right side, between the pedicle and the transverse tubercle of the vertebra behind, and the part of the rib representing its neck and tubercle in front, there is a narrow space; on the left side this is filled up by bone. These ankylosed ribs have a general resemblance to lumbar transverse processes, in at least their projecting portions, but inwardly they begin from the anterior instead of from the posterior part of the pedicle.

(e) Variation in the position at which the change from the dorsal to the lumbar direction of the Articular Processes takes place. This change normally occurs between the 12th dorsal and 1st lumbar vertebrae, and is not accomplished by an intermediate position of the two processes, but entirely by the process of the vertebra above assuming the lumbar type. This character, however, of the 12th dorsal vertebra is not invariable. The following ten cases are examples.

Cases 1 and 2. In the two first related cases of imperfectly developed 12th rib we have seen that the change takes place between the 11th and 12th dorsal vertebrae. In the first of these cases the change is complete and symmetrical, in fact the lower processes of the 11th look more decidedly outwards than those of the 12th and 1st lumbar. In the second case it is symmetrical but less complete, though more resembling the lumbar than the dorsal.

Case 3. In this case (yet to be noticed, case 8 of lumbar variation; vertebrae C. 7, D. 11 or 12, L. 5 or 4, S. 6, C. lost) the change takes place, and completely, with the lower processes of the 11th dorsal. A slightly movable 12th rib exists on one side only.

Case 4. Female skeleton. Grouping of vertebrae normal. Articular processes change between 11th and 12th dorsal, on left side completely, on right side not completely, but more resembling lumbar than dorsal.

Case 5. In an otherwise normal spine (young, 20 inches in length) the change is not fully accomplished till between the 1st and 2nd lumbar vertebrae, the processes between the 12th dorsal and 1st lumbar partaking more of the dorsal than of the lumbar direction. Costal facets normal.

Case 6. In this robust adult spine, the change is only half accomplished between the 12th dorsal and 1st lumbar vertebrae, the direction of the processes being exactly intermediate. Costo-capitular facets on 12th vertebra well marked.

Case 7. The case to be described under lumbar variation, No. 1, presenting 13 ribs, contains an example of the change taking place chiefly a vertebra lower than usual.

Case 8. The skeleton in Dr Barclay's museum, having an additional dorso-lumbar vertebra and 13th rib, presents an example of the change taking place a vertebra lower than usual. This skeleton is noticed in foot-note to case No. 3 of lumbar variation.

Case 9. In another robust adult spine (C. 7, D. 12, L. 5) the change takes place between the 11th and 12th dorsal on one side, the left, but not on the other. Yet, as far as their direction is concerned, the processes of the space above and of the space below are symmetrical. But there has been some lateral curvature of the spine towards the right side, and the edges of the bodies throw out excrescences on that side. Costo-capitular facets on 12th dorsal vertebra well marked, the right the larger and deeper. Tenth dorsal vertebra has the costo-capitular facet entire on the right side, and no facets on its well-developed transverse processes. The transverse process of the 12th seems to develope a shorter metapophysis on the side on which the articular processes between it and the 11th have changed to the lumbar type; but this necessarily follows; the change in the direction of the process filling up the space which otherwise separates the metapophysis and the superior articulating process.

Case 10. Adult male skeleton in the Anatomical Museum of the University. Ribs and grouping of vertebrae normal. The same want of symmetry is seen in this case as in the last, but between the 12th dorsal and 1st lumbar vertebrae. The articular processes of the left side retain the dorsal type, facing front and back, while those of the right side have assumed the lumbar type. The articular processes of the space above and of the space below are normal and symmetrical. Costal facets normal. Twelfth ribs 5 inches in length and symmetrical. There is no abnormal curvature or disease. The skeleton is a tall, robust, well-proportioned, and healthy one[1].

[1] *Articular Processes in Animals.* It is interesting to observe the various situations at which the change of direction of the articular processes takes place in different animals. My limits prevent me from going into this comparison more fully at present, but I may state generally that the change from the thoracic to the lumbar type of process takes place in most quadrupeds more or less in front of the last thoracic, leaving from 1, or more generally from 2, to as many as 5 of the dorsal vertebrae with articular processes of the lumbar type, these generally corresponding to where the ribs are small or less firmly articulated. Along with this, generally but not always, is seen the convergence of the spinous processes to the point where the change of the articular processes takes place, of which the feline back presents an exact and striking illustration. In others, again, of which the Indian Tapir is a striking example, the thoracic type commences in the lumbar region; in the tapir (Vertebrae C. 7, D. 18, L. 5) commencing as far back as between the two posterior lumbar vertebrae. In this animal all the spinous processes slope backwards, and all the ribs have the head intervertebrally placed, and all of them except the last have a costo-transverse articulation. But that the place of change is not regulated only by number of ribs and length of the ilio-costal space is seen, for instance, in the Kangaroo and Wombat, in both of which the place of change is between the 11th and 12th dorsal, leaving behind it, in the kangaroo 2 dorsal and 6 lumbar, in the wombat 4 dorsal and 3 or 4 lumbar and a short ilio-costal space. In most the change is sudden as in Man, but in some it is gradual, extending over two or even three spaces. The part to which the anterior spinous processes slope back and the posterior slope forwards is sometimes termed the centre of motion, and the vertebra to which they incline the "anticlinal" vertebra. The convergence of the spinous processes is no doubt the most striking feature, and the other processes change more or less here, but the change of the articular processes is the fundamental one.

The change from the cervical to the thoracic type of articular process is not so gradual as in man, but is generally abrupt and situated some way within the thorax; generally between the 1st and 2nd dorsal vertebrae, in some between the 2nd and 3rd; or it may be divided between the 1st and 2nd and the 2nd and 3rd, or between the 2nd and 3rd and the 3rd and 4th, but still strikingly visible. In man it is not easy to recognise the change from cervical to dorsal articular processes, at least from the oblique to the vertical, though the shifting of the processes inwards is evident below the 1st dorsal on comparing the lower with the upper processes of that vertebra.

(C.) Variations in the Lumbar Region.

(a) Lumbar Ribs. Case 1. *Lumbar Rib on both sides, but unequal, giving thirteen pairs of ribs.* Adult female. Preparation shews 7 cervical, 4 lumbar, and 13 vertebrae bearing ribs, and the parts bounding superior aperture of thorax. First thoracic rib incomplete on right side. *Thirteenth rib*, on right side, the larger, length almost 3 inches, average breadth 3 lines, at middle 4. On left side, length 1¼ inch; breadth at middle over 2 lines, expanded at outer end to 3 lines. Head of each rests on vertebra at upper and fore part of pedicle, upper part of head resting on parapophysial elevation, most marked for the smaller rib. Each has likewise a synovial costo-transverse articulation, a distinct facet on the rib articulating with the external tubercle which represents a rudiment of a transverse process, ligamentous fibres intervening between the two articulations. The lumbar ribs recede to this point and then turn outwards and forwards. Both 13th ribs slant downwards like the 12th ribs, in contrast with the transverse processes of the vertebra below, which are horizontal and about ½ inch in length. Tip of shortest 13th rib projects nearly ½ inch beyond tip of transverse process below it. *Twelfth ribs*, on right side 5¼ inches in length, breadth nearly ½ inch at middle; on left side outer part now removed but it was, like the left 13th rib, shorter and more slender than its fellow. *Vertebrae.* Articular processes assume lumbar type a space lower than usual. The change is partially effected at the usual place on the right side, but on left side the processes still have strictly the direction of dorsal processes. Spine of 12th dorsal vertebra has sloping upper edge; spine of vertebra below it is square-shaped and nearly horizontal. *First thoracic rib*, on right side is imperfect. For

The study of the direction of the mammalian articular processes is much facilitated by beginning with an earlier type, as in the Crocodile. There all the processes—cervical, thoracic, lumbar, caudal—are on the same general and simple type. The anterior pair form the sides of a socket (zygantrum) facing inwards and more or less upwards, the posterior pair forming a wedge (zygosphene) fitting into the socket. It is now easy to see by what simple changes, in one or two directions, processes corresponding to those in the different regions of mammals may be obtained; those of the posterior regions having departed least, those of the thoracic region most, from the early type.

$\frac{3}{4}$ inch in front it is represented by a ligament which joins internally the narrow first costal cartilage, most of which is ossified, more so than the cartilage of the other side is. Shaft is slender, $2\frac{1}{2}$ inches in length, $\frac{1}{4}$ inch in breadth at the subclavian groove. This deficiency of 1st rib is on that side on which the 13th rib is longest. Transverse process of 7th cervical vertebra presents well-marked bifurcation, with small-sized foramen. Anterior transverse processes of atlas incomplete on both sides.

Case 2. *Lumbar Rib on both sides.* No history. Preparation of an otherwise characteristic robust 1st lumbar vertebra. Left rib the longest and thickest, length $2\frac{3}{4}$ inch, right $2\frac{1}{4}$. Both expanded at outer third to breadth of $\frac{1}{2}$ inch, thicker and a little narrower along inner $\frac{2}{3}$, right the more slender as well as the shorter. *Relation to the vertebra.* Each presents a terminal facet, articulating with a parapophysial elevation placed where the upper and fore part of the pedicle joins the body, and a posterior facet, close to the other, which articulates with a slight eminence on the lower and back part of the pedicle. On the left side, however, these two surfaces on the pedicle appear to have been continuous by a narrow connection. Back of rib external to this is in relation with the transverse process, which is $\frac{1}{2}$ inch in length, but with a narrow interval between. No facet here, but marks of ligamentous attachments. The parapophysial eminence, pedicle, and transverse process together form a somewhat square-shaped socket into which the elongated head of the rib is received, but without contact with the transverse process, and motion must have been limited. The elongated head of the rib gives the appearance as of a head and tubercle without a neck, but both the facets appear more strictly to belong to the head, the costo-transverse articulation having been ligamentous only[1].

[1] *Two cases of Lumbar Rib in the Ox; in one the rib placed on the end of the transverse process, in the other placed in the usual situation.* 1. The rib in this case, as in case No. 8 following in this series, is placed on the end of the transverse process, and on one side only, but it is a supernumerary rib and there is no serial variation of the vertebrae. Skeleton of a short-horn cow in the Anatomical Museum of the University. Vertebrae C. 7, D. 13, L. 6, the first carrying the rib. Transverse process of first lumbar vertebra $2\frac{1}{2}$ inches in length on right side. On *left* side a movable rib, 4 inches in length, is supported on a transverse process 6 inches in length. First inch of latter is like the root of the transverse processes; then follows an enlargement as if the

(b) More complex Lumbar Variations. Vertebrae and Ribs. Case 3. *A Dorso-lumbar Vertebra more than usual, with additional pair of Ribs.* Male aged 50. Preparation shews, cervical vertebrae 7, dorsal 12, lumbar 6, the first having lumbar ribs, sacral 5, coccygeal 3 or 4, probably 4. *Thirteenth ribs,* nearly symmetrical, but right a little longer and thicker than left. Right, length 2 inches; breadth of shaft at inner two-thirds, $\frac{1}{6}$ inch, at outer third $\frac{1}{4}$. Left, length $1\frac{7}{8}$, a little less in breadth that right. Both are thinner as well as more expanded at outer third than along inner two-thirds. They slope a little downwards, but direction not very fixed as they are freely movable. They reach out 1 inch beyond tips of transverse processes of vertebra below. The latter slope a very little downwards, are 1 inch in length, measured from the body, and $\frac{1}{2}$ inch in breadth. *Articulations.* Head surrounded by ligament. Also interosseous and costo-transverse ligaments, occupying all the length of the transverse process and outwards from it. Length of transverse process $\frac{1}{4}$ inch. Head rests by articular facet on parapophysial eminence situated where upper and fore part of pedicle joins body. As the dissection was not so fresh as I could have wished I could not satisfy myself whether at any part external to the head there was a second synovial membrane or only loose connective tissue, within the ligament, but there was no second cartilaginous facet. The motion of the rib, with the ligaments entire, was very free. *Twelfth rib,* length of right 7 inches; breadth along inner part of shaft 5 lines, outer part $\frac{1}{2}$ inch. Left now removed. Large cartilaginous facet for head, and same synovial cavity reaches out to end of transverse process, but there is no

rest of the process had been separate and become ankylosed here. This long transverse process is curved backwards like the 13th rib, and as broad as it, while the transverse process behind it, 4 inches in length, is curved with concavity forwards. As the movable rib and transverse process now present irregular bony ends, they have probably been united by cartilage. 2. Occurs in a Bos grunniens, on both sides. Vertebrae C. 7, D. 14, L. 5. The supernumerary (14th) rib is long and well formed; length along curve $10\frac{1}{2}$ inches, straight 9, being only $1\frac{1}{2}$ inches shorter than 13th rib. Shaft as broad as that of 13th along vertebral half, and nearly as broad as 13th along lower half. Head intervertebral. Costo-transverse articulation present on right side, none on left; present on 13th rib on both sides.

In this *Journal* for November 1871, I recorded a case in which I found a supernumerary (16th) pair of ribs in a Great Fin-Whale (Balaenoptera Musculus). In this case the supernumerary ribs floated among the muscles, unconnected with the vertebrae.

external facet. Same on both sides. Transverse process, as on vertebra supporting lumbar ribs, $\frac{1}{4}$ inch in length; metapophysis and anapophysis also well marked on both. *Eleventh rib*, costo-transverse facet present on right side, $\frac{1}{2}$ inch out from the head; none on left side. *Tenth rib*, no costo-transverse facet on either side; head rests partly on 9th vertebra on both sides.

Sixth lumbar vertebra. (25th vertebra.) Freely movable. Has the characters of a normal last lumbar vertebra, including normal transverse processes. Lower articular processes $\frac{1}{4}$ inch wider apart than upper, but are not wide apart ($1\frac{5}{8}$ inch), and look very much inwards. Lower processes of fifth also $\frac{1}{4}$ inch wider apart than upper. Antero-posterior thickness of pedicles, 9 lines; those of fifth, 7 to 8 lines; those of fourth, 4 to 5 lines. Lumbo-sacral fibro-cartilage same length at middle as those above, but less at the sides. Distance between transverse processes and sacrum nearly $\frac{1}{4}$ inch. Two entire nerves, being the 5th and a 6th lumbar, went down to join the sacral plexus. The obturator arose from the 3rd and 4th, the anterior crural from the 2nd, 3rd, and 4th. *Sacrum.* The 5 pieces completely ossified together. Greatest breadth $4\frac{1}{2}$ inches; length at anterior surface, straight $3\frac{1}{4}$ inches, along curve $4\frac{1}{4}$; depth of curve $1\frac{1}{4}$. Promontory well marked. Upper surface of wings a little more sloping than usual. Auricular surface extends down to nearly opposite lower edge of 2nd foramen. Canal opens at 3rd space. Horns short, outer boundary of 4th foramen $\frac{1}{2}$ inch broad. Lower end, breadth 9 lines; less motion here than between 1st and 2nd pieces of coccyx. *Coccyx*, in three movable pieces, the third apparently composed of two. Total length $1\frac{1}{2}$ inch. First piece, length 6 lines; breadth including short transverse processes, 15 lines; very short horns, connected to sacral horns by ligament. Second piece, length 4 lines, breadth 8 lines. United third and fourth pieces, length 7 lines, of which 4 belong to third; line of ankylosis indicated by deep notch at either side, by a furrow in front, and by a deep fissure behind going more than half through the thickness of the bone. Third piece diminishes in breadth from 6 lines to 4. Fourth piece, breadth at first 5 lines, semilunar termination. After comparison with other specimens of more or less ankylosed coccyx it must be concluded that this coccyx has had four pieces.

We have, therefore, in this case an instance of an additional lumbar vertebra, with an additional pair of ribs, together with the full number of sacral and, apparently also, of post-sacral vertebrae[1].

Case 4. *A Dorso-lumbar Vertebra more than usual, with additional pair of Ribs; the sixth lumbar vertebra partly united to the sacrum.* Male aged 29. Preparation shews entire spine with vertebral ends of ribs, the vertebrae still united by their fibro-cartilages. Vertebrae, cervical 7; dorsal 12; lumbar 6, the first carrying ribs, the sixth partially united to the sacrum; sacrum 5, exclusive of sixth lumbar; coccyx 4, first separate,

[1] *Case of additional dorso-lumbar vertebra and additional rib in Dr Barclay's Museum.* I was acquainted with a skeleton in the Barclay Collection in the Edinburgh College of Surgeons, marked "Skeleton of a European male used by Dr Barclay in his lecture-room, as having thirteen dorsal vertebrae and thirteen ribs on the left side." My notes of it contain the following. Vertebrae C. 7, D. 13, L. 5, S. and C. ankylosed together. Seven well-formed cervical vertebrae. The seven upper ribs join sternum in usual manner. Twelfth rib over 6 inches in length along the curve, and same on both sides. *Thirteenth rib*, length $1\frac{7}{8}$ inch, breadth $\frac{1}{3}$ inch. Head rests on a short parapophysial elevation, and a short transverse process is in close relation with the rib posteriorly. Appearances indicate that a corresponding supernumerary rib has been present on right side also, but probably not so much developed. Lower articular processes of 12th dorsal do not undergo the change to the lumbar type, those of 13th the first to do so, but the processes between the 12th and 13th are smaller than those higher up and are not quite symmetrical. Lower articular processes of 4th lumbar (24th vertebra) $1\frac{3}{8}$ inch apart, and only $\frac{1}{8}$ inch wider apart than its upper processes. Lower processes of 5th lumbar 2 inches apart, and about $\frac{1}{2}$ inch wider apart than its upper processes. Sacrum and coccyx ankylosed in one piece; 5 pairs of foramina and an irregular mass beyond. Uncertain whether this mass comprises 2 or 3 pieces. Coccyx twisted to right side, making 4th and 5th foramina much smaller on right than on left side. Canal of sacrum opens opposite upper edge of 5th foramen. Sacro-iliac articulation reaches down to midway between 2nd and 3rd anterior sacral foramina.

We have in this case an instance of a dorso-lumbar vertebra more than usual, with additional rib; but as it is uncertain whether the sacro-coccygeal vertebrae have been 9 or only 8 in number, it is uncertain whether there has been also an absolute addition to the number of the vertebrae.

Case of additional dorso-lumbar vertebra, with additional pair of ribs, in a Cat. This variation is seen in the skeleton of an adult cat in my possession. The vertebrae and ribs are still connected by their fibro-cartilages and ligaments. Vertebrae, C. 7, D. 13 or 14, L. 7 or 6. Change of articular processes from dorsal to lumbar between 11th and 12th dorsal, as usual. Supernumerary rib (14th), like the two in front of it, rests on body of vertebra only. Is $1\frac{1}{2}$ inch in length on right, 1 inch on left side, the latter just half the length of the 13th rib; and seems to have ended as a free floating rib. In the place of its attachment to the body of the vertebra, it is serial with the rib in front of it and with the transverse process behind it. The latter process is a little shorter than those behind it, but resembles them in direction and in springing from, in the developed skeleton, the side of the body of the vertebra. The seven lumbar vertebrae have the usual characters; and the sacrum its usual three vertebrae, ankylosed above and below.

three last ankylosed to each other. *Lumbar ribs* nearly symmetrical, but tip of left has been sawn off. Length of right 1½ inch, projecting ¾ inch farther than tip of transverse process of vertebra below it. Breadth 3 to 4 lines, a little broader and thinner at outer fourth. Transverse process below has same breadth but is thinner. Rib and process below both directed horizontally. *Relation to vertebra.* Same on both sides. Head forms triangular enlargement which is received into a kind of socket, formed, behind by the short transverse process, internally by a parapophysial elevation. Latter crosses pedicle obliquely downwards and backwards, presenting a partially divided but continuous cartilaginous surface, ½ inch in length, ¼ inch in breadth, on which end of rib articulates. The posterior surface, meeting this nearly at a right angle, is in close relation with the transverse process, which is ¼ inch in length, but there is no articular facet between them. Only up and down motion could occur here, and it cannot have been free. *Dorsal vertebrae.* No articular facet on transverse process of 10th on left side, but well marked on right; head of 10th rib touches 9th as much as 10th body, on both sides, although head of this rib on right side is exceptionally narrow.

Fifth lumbar vertebra. Transverse process has the usual upward slope and triangular form, but is much less robust than usual for the fifth as seen in front. Seen from above, there is that antero-posterior thickness of the pedicle which belongs to a normal 5th lumbar. *Sixth lumbar vertebra* (25th vertebra). Relation to sacrum—Fibro-cartilage in front is half the thickness of those above, narrow at the sides, becoming encrusted with ossification behind. Articular processes free; lower ½ inch nearer each other than the upper are, in contrast with those of 5th, which are ¼ inch wider apart than its upper processes. Distance between upper processes of sixth, 2¼ inch, at outer edges. Transverse process, on right side, massive, bluntly bifid; 8 lines in height at foramen, expanding outwards to form a wing 14 lines in height; articulates below with a concave surface on outer and back part of sacrum, ½ inch broad, forming outer boundary of a lumbo-sacral foramen. On left side transverse process larger, expanding into a wing 16 lines in height, and similarly bifurcated; line of articulation with sacrum, 1 inch in breadth, and undergoing ankylosis. The line of suture is uneven, the approach being mainly by the descent of the transverse process behind and internally, and mainly by the ascent of the sacrum in front and externally. Foramen 5 lines across on this side, 7 lines on right; neither of them so large as 1st and 2nd sacral foramina, but fully as large as 3rd. Besides the nerve which occupied this foramen, the whole of the 5th nerve and part of the 4th passed down to the sacral plexus. *Sacrum*—5 pieces. Apart from the above-mentioned transverse process relations, it would pass for a well-formed though small-sized sacrum. Greatest breadth $4\frac{1}{4}$ inches, length in front $3\frac{3}{8}$ straight, along curve 4; greatest depth of curve $1\frac{1}{8}$. Upper surface of wing less sloping than usual on right side, more than usual on left side. Sixth lumbar vertebra is in line with the lumbar curve, and away back from the general curve of the sacrum. Auricular surface reaches down fully to opposite middle of 2nd foramen. Portion of sacrum has extended up so as to come in between lower part of left transverse process of sixth lumbar vertebra and ilium, but a small part of right has articulated with ilium continuously with where it articulates with sacrum. Canal opens at 3rd segment. No horns towards coccyx. Outer boundary of 4th foramen $\frac{1}{3}$ inch in breadth. Lower end, 8 lines transversely. *Coccyx.* Total length $1\frac{1}{8}$ inch. Four pieces. First piece separate, length over 4 lines, breadth, including transverse processes, 14 lines; horns very short. Last three pieces ankylosed; indicated by constrictions, marked enough in front, very distinct behind. Second piece, length under 4 lines, breadth 6 lines, tapering to 4. Third piece, length 3, breadth 4. Fourth piece, length between 2 and 3 lines, breadth 5.

We have in this case another instance of an additional lumbar vertebra, and an additional pair of ribs, together with the full number of sacral and post-sacral vertebrae. Or, if the 6th lumbar be regarded as the 1st sacral only partially consolidated, we have then a case presenting that condition, together with an additional pelvic vertebra, and a 13th pair of ribs.

Case 5. *Six Lumbar Vertebrae.* Male aged 56. Vertebrae C. 7, D. 12, L. 6, S. 5, C. 3. Dorsal vertebrae and ribs normal. Twelfth rib $5\frac{1}{2}$ inches in length. *First lumbar vertebra* normal except that it has no vestige of transverse process on either side, although there is a fair metapophysis and anapophysis. From this, and the presence of markings on the fore part of the pedicle, I am inclined to infer that there have been small lumbar ribs here, though they were not noticed in dissection. The appearances here are precisely like those on the corresponding parts of the 12th dorsal vertebra in case No. 1 of undeveloped 12th thoracic rib, supposing the minute rib to have been removed here. I have an otherwise normal spine in which the first lumbar vertebra shews this condition on the right side; with an ordinarily developed first lumbar transverse process on the left, there is, on the corresponding part on the right side, an irregular concave facet as if a movable process had been attached there.

Sixth lumbar vertebra. Is quite separate from sacrum. Lower articular processes $\frac{1}{10}$ inch less apart than upper. Distance between upper, $2\frac{1}{8}$ inches. Lower of fifth $\frac{1}{4}$ inch wider apart than upper. Transverse processes are more robust than usual; while those of the vertebra next above it are unusually short and narrow externally, with moderate increase of thickness at pedicle. Left process, length from body 1 inch, height 6 lines, thickness 4 to 5 lines. Right same length, commencing to bifurcate, giving height of $\frac{3}{4}$ inch, and is also thicker than left. These are not in contact with sacrum, but by bending to either side they are made to touch; articular facets are seen below their ends, and corresponding facets on the sacrum and partly on the ilium, just above the end of the sacro-iliac articular surface. On the left side these are small and form separate joints. On right side the articulation is for $\frac{1}{3}$ inch with a concave facet on outer and back part of sacrum, and, externally and continuously, with a flat facet of the same size on the ilium. Although the latter now appears separated by a rough furrow from the sacro-iliac joint, it was noted in the dissection that they were continuous. Sacro-iliac articular surface goes down to opposite a little below lower edge of 2nd foramen on left side, to below middle of foramen on right side. A rather scattered sacro-lumbar ligament passed up to the transverse process, and an ilio-lumbar ligament passed in to the transverse process of the 6th, none to that of the 5th, which is unusually short and narrow. Thickness of fibro-cartilage, at middle, between sacrum and 6th vertebra nearly ½ inch. Both 5th and 6th nerves went entirely down to the pelvis, the 5th a smaller nerve than it usually is. Obturator arose as usual from 3rd and 4th. Abdominal aorta divided as usual at the lower part of the 4th lumbar vertebra.

Sacrum. The 5 pieces quite ankylosed. Breadth 4¼ inches; length in front 3⅛ straight, along curve 4⅛. Greatest depth of curve 1¼. Promontory sharp. Upper surface of wings not more sloping than usual, if so much. Canal opens at 4th segment. Outer boundary of 4th foramen broad, ⅓ inch on left, ½ inch on right side. Horns short and unequal. Lower end, ½ inch in breadth. *Coccyx,* of 3 pieces, ankylosed to each other. Total length 1 inch behind, ⅛ less in front. First piece, length nearly 4 lines in front, 5 behind; breadth 11 lines; transverse processes very unsymmetrical, right narrow, left thick and robust, giving coccyx an obliquity to right side. Horns very short. Second piece, length 4 lines, breadth 7 lines. Third piece, length 3, breadth 6 lines. Ankylosis of 1st and 2nd the more complete, and much resembles that between 3rd and supposed 4th in case No. 3.

This case is an example of an additional lumbar vertebra, gained from the sacrum, the sacrum being compensated by borrowing one from the coccyx.

Case 6. *Six Lumbar Vertebrae.* Preparation shews the vertebrae and vertebral ends of ribs still united by their fibro-cartilages, upper 6 cervical removed, 4th coccygeal lost. From the size I infer that it is from a female subject. Vertebrae, dorsal 12, lumbar 6, sacral 4, coccygeal 4. Dorsal vertebrae normal. Transverse processes of 1st lumbar ⅓ inch in length behind; those of 5th much narrower than those of 3rd and 4th, but have the usual upward slope and greater obliquity of lower margin, and moderate antero-posterior increase at the pedicle. *Sixth lumbar vertebra.* Transverse processes thick, 1 inch in length from the body; height on left side ¾ inch, on right 1 inch with commencing bifurcation. The right by its lower and outer part articulates by a synovial joint, below with the sacrum for ¼ inch, and outwardly for a like distance with the ilium, the two joints being continuous. This is just above the upper end of the sacro-iliac joint, with which the lumbar process articulations appear to have been continuous. On the left side there is a space of $\frac{1}{6}$ inch between the process and the sacrum, and apparently no facets. Iliac articular surface on sacrum reaches down on right side to opposite middle of 2nd foramen, on left side to opposite lower boundary of foramen. Lower and upper articular processes of sixth equidistant. Lower of fifth, $\frac{1}{10}$ inch wider apart than upper. Distance between upper of sixth, $1\frac{3}{4}$ inch. *Sacrum* 4 pieces, fully ankylosed. Breadth $4\frac{1}{4}$ inches, length in front, straight 3, along curve $3\frac{5}{8}$; greatest depth of curve 10 lines. Canal opens at 4th piece. Promontory well marked, upper surface of wings less sloping than usual. Horns well developed. Lower end, a little expanded laterally, breadth 1 inch, sharp-edged and nearly flat. Fourth foramen a wide notch which lateral processes of first piece of coccyx would complete into a foramen if prolonged for $\frac{1}{4}$ inch on left, for $\frac{1}{2}$ inch on right side. Second sacral foramen fully larger than 1st, although it is here the foramen of the third nerve. *Coccyx.* Pieces still separate. First piece, length 8 lines, breadth between tips of wings $1\frac{5}{8}$ inch, each lateral process 4 lines at upper margin. Breadth of upper articular surface 1 inch; lower end $\frac{1}{2}$ inch in breadth and bevelled like normal lower end of sacrum, and motion more free here than between this vertebra and the sacrum. Its characters are thus transitional between 5th sacral and 1st coccygeal, but serially it is the 1st coccygeal (30th vertebra) and it is movable on the sacrum. Second piece, length 6 lines, breadth 9 lines tapering to 5. Third piece, length 4 lines, breadth 6 lines tapering to 3. Fourth piece was hanging loose and has now been lost; cartilaginous surface visible on which it rested.

This case presents an instance of an additional lumbar vertebra, obtained from the sacrum, while the sacrum has not borrowed a compensatory piece from the coccyx.

Case 7. *Six Lumbar Vertebrae.* A spine in the Anatomical Museum of the University; no history. Vertebrae C. 7, D. 12, L. 6, S. 5, C. lost. Dorsal and upper lumbar vertebrae normal. Marked increase of thickness of pedicle of 5th lumbar. *Sixth* *lumbar.* Transverse processes thick, about as thick as little finger, and slanting very obliquely upwards. Right has short bifurcation, upper division narrow, lower close to sacrum with corresponding rounded facets $\frac{1}{2}$ inch in diameter. Process is $\frac{1}{2}$ inch short of reaching out to level of sacro-iliac joint. Left thick, instead of bifurcating, and is quite close to sacrum for $\frac{1}{2}$ inch, with a facet. Included lumbo-sacral foramina elliptical and very oblique upwards and outwards. Articular processes not wide apart. Distance between upper processes of sixth, less than $1\frac{1}{2}$ inch. Lower processes $\frac{1}{4}$ inch wider apart, directed nearly straight forwards, and not quite symmetrical. Lower processes of fifth are $\frac{1}{6}$ inch wider apart than upper. *Sacrum* 5 pieces. Breadth $4\frac{3}{8}$; length in front, straight $3\frac{5}{8}$, along curve $3\frac{7}{8}$; depth of curve 7 lines. This is a remarkably flat sacrum; the slight curve is where the 4th and 5th pieces join. Promontory well enough marked; upper surface of wings more sloping than usual at back part only, brim-line being well formed. Sacro-iliac articular surfaces appear to stop even before reaching to opposite upper edge of 2nd foramen, a sharp and prominent ridge here cutting them off from a doubtfully articular excavated surface which is continued $\frac{3}{4}$ inch farther, to opposite lower edge of 2nd foramen. Canal opens at 4th piece. Upper two pairs and lower two pairs of foramina of usual size. Lower end $\frac{1}{2}$ inch transversely. No horns towards coccyx. Coccyx lost.

This case presents an instance of a sixth lumbar vertebra, obtained from the sacrum, while the sacrum is numerically compensated by borrowing a vertebra from the coccyx.

Case 8. *A Dorsal or Lumbar Vertebra less than usual; Eleven pairs of ribs; 12th dorsal, or 1st lumbar, vertebra with movable transverse process on one side.* Robust spine with vertebral ends of ribs, the vertebrae still united by their fibro-cartilages. Vertebrae C. 7, D. 11 or 12, L. 5 or 4, S. 6, C. lost. Tenth ribs do not touch 9th vertebra, and have no costo-transverse facet. Vertebral part of 11th ribs preserved for 2 inches, robust, left more so than right. *Eleventh dorsal vertebra.* Lower articular processes assume lumbar type (as already noted, case 3 of that variation). Metapophysis long and projecting but would be more so on vertebra below but for the filling up implied in the change of the articular process. Transverse process a conical tubercle $\frac{1}{4}$ inch long on left side, still shorter on right. Heads of 11th and also of 10th ribs rest on the pedicles, in sockets the fore part of which is formed by a parapophysial elevation situated where upper part of pedicle joins body. *Twelfth dorsal or 1st lumbar vertebra,* presents on left side a transverse process which resembles that of vertebra below in its place of origin and its upward slope, but is longer than it by $\frac{1}{8}$ inch (length from the body $1\frac{1}{4}$), and nearly a third broader (breadth $\frac{1}{2}$ inch); and is also thicker, so that its base extends farther forwards on the pedicle than that of the process below, or than that of an ordinary first lumbar transverse process. On the *right* side, the corresponding part is in two pieces. Inner portion, $\frac{1}{2}$ inch in length, is thick, rising from nearly the whole of the pedicle. It is thicker antero-posteriorly than the base of the left process, reaching especially more forwards on the pedicle. Articulated on the end of this long parapophysial eminence is a movable process 1 inch in length, its form and proportions extremely like those of the entire lumbar transverse processes below it, or of any ordinary lumbar transverse process. The intervening articular surface, as now seen, 8 lines in length backwards and downwards, 4 lines in breadth, most of it smooth and covered by cartilage, and undulating so that the motion must have been only up and down and very limited. This apparently has been an instance of what is termed development of the first lumbar transverse process from a separate centre. There is no reliable trace of ankylosis having taken place between two similar parts on the left side. Lowest lumbar vertebra (23rd vertebra) presents the usual characters of a normal 5th lumbar. Lower articular processes $\frac{1}{2}$ inch wider apart than the upper. Distance between the upper, $1\frac{7}{8}$ inch. Pedicles present the usual increased thickness of those of a lowest lumbar vertebra.

Sacrum, 6 pieces. The unusual shape of the 1st piece, and the dorso-lumbar vertebra less, lead to the inference that the extra piece has been borrowed from above. Breadth of 1st piece $4\frac{7}{8}$ inch, of 2nd piece an inch less; length in front, $5\frac{1}{8}$ straight, along curve $5\frac{5}{8}$, without 6th piece 8 lines less; depth of curve 1 inch. Curve is gained on lower 2 pieces, the general appearance of the front being that of great flatness. Body of first piece, instead of prolonging general curve of sacrum, lies back towards lowest lumbar vertebra, which it meets at a very obtuse angle, forming but a slightly projecting promontory. Upper surface of wings slopes downwards and outwards, but more especially forwards, forming a very obtuse angle with front of sacrum. Thickness of neck of 1st piece, opposite the foramen, is really less than that of 2nd piece (9 lines) as seen from before and below; but as seen from above, the 1st piece appears much the thicker of the two, owing to the obliquity. Auricular surface reaches down to opposite upper edge of 3rd foramen; angle is on first piece; upper part goes off at a very obtuse angle and is rather short, reaching on the anterior and lower half of the wing. Brim-line on first piece, runs from angle of auricular surface inwards and upwards to upper edge of first foramen, where it is lost. What the transverse mass of this 1st sacral vertebra wants, is that thickness of the fore part which normally carries the anterior surface of the sacrum so high above the 1st foramen as to give nearly a right angle with the upper surface, the rounded-off angle forming the brim of the true pelvis. But in this specimen there is but one surface, sloping from the upper boundary of the foramen to the upper border of the wing, almost in line with the front of the transverse processes of the lumbar vertebrae. This is the part occupied by the sacral rib in development, and as this vertebra is serially the 5th lumbar (24th vertebra) the absence of this element in its development would be sufficient to account for this peculiar form. The first three foramina are large, the 2nd less than the 1st and 3rd. Canal opens at 4th piece. No distal horns. Outer boundary of 5th foramen $\frac{1}{3}$ inch broad on left side; on right, foramen only half enclosed from below. Lower end nearly 7 lines transversely. Coccyx removed.

This case presents an instance of deficiency of a dorso-lumbar vertebra, accompanied by a variety in which the 12th rib and transverse process are convertible; and in which the seemingly absent vertebra has been united to the sacrum.

Case 9. *Six Cervical Vertebrae, and six Lumbar Vertebrae;*

and a Vertebra suppressed in some part of the column. Female aged 40. This case presents variation of several regions of the spine, but will be most conveniently noticed here. It might be defined simply as a spine on which the thorax is planted a vertebra higher than usual; but the first rib on one side has the characters of a half-developed supernumerary cervical rib; the articular processes change in the usual space, between the 19th and 20th vertebrae; two entire lumbar nerves went down from the lumbar region to the sacral plexus; and, while the sacrum has 5, the coccyx has only 3 pieces. As it actually stands, the grouping is, C. 6, D. 12, L. 6, S. 5, C. 3. The preparation presents the entire spine with the vertebral end of the ribs.

Sixth cervical vertebra. Anterior transverse process much less robust, especially on left side, than that of 5th. Lateral foramen double, anterior the smaller on left side; artery has not entered till 5th on left side (see case No. 16 of variation of lateral foramina in neck). *Seventh vertebra* (supporting 1st pair of ribs). Transverse processes directed a little downwards and nearly straight outwards, while those of vertebra below are slanted upwards and backwards; robust, but not so much so as those of vertebra below; long, between tips $2\frac{3}{4}$ inch, being a line more than in vertebra below. The inward shifting of the articular process, from cervical to dorsal, is, as usual, most marked below the 8th vertebra, very little between 7th and 8th.

First pair of ribs. Left, small, ceasing at middle of shaft. Head rests on upper part of body; right, broad, on a parapophysial eminence; left, narrow, sunk in a depression. Good costo-transverse articulation; head neck and tubercle 13 lines, right like an ordinary first thoracic rib, left narrower. Shaft of right has been sawn across after $1\frac{1}{2}$ inch, is rather narrower than ordinary first rib in female; breadth at subclavian groove 5 lines, at low scalene tubercle in front of this, 7 lines; groove for artery broad and moderately marked. Shaft of left, length $1\frac{5}{8}$, breadth at middle $\frac{1}{4}$ inch, tapers to subclavian groove, which is well marked, and in front of this forms flat terminal expansion, 5 lines in breadth. Inner part of this expansion is a muscular ridge, the lower aspect articulates with conical process of 2nd rib, and, anteriorly, an uneven surface is seen which has evidently given attachment to a small cartilage, or to a ligament, prolonging the rib. Conical process of 2nd rib, $\frac{1}{4}$ inch in height, top truncated, forming flat oval facet, $\frac{1}{3}$ inch in length, on which end of 1st rib rests by a now irregular surface. Intercostal space, length, from costo-transverse articulation to conical process, $1\frac{1}{2}$ inch, and $\frac{1}{2}$ inch in height at middle. On left side, 1st rib thus presents all the characters of a half-developed supernumerary rib, as in case No. 9, and on right side of case No. 10, of that variety. I have no note respecting the anterior part of the right first rib, the parts having been removed, but it has all the appearance of a rib which would reach the sternum. Head of 2nd rib has probably touched the 7th vertebra, at least on left side. The 3 lowest ribs have the same relation to their vertebrae which the normally placed 3 lowest have to their vertebrae. Head of 12th ribs, and the $1\frac{1}{2}$ inch of their shaft which the saw has left, are of good size.

First lumbar vertebra (the 19th vertebra) has the ordinary transverse processes of an uppermost lumbar vertebra; length 5 lines behind, and $\frac{3}{4}$ inch along lower edge from body; about $\frac{1}{4}$ inch in breadth; and they spring from behind middle of pedicle. Direction horizontal. Metapophyses project, as they also do on the vertebra in front, the change of the articular processes not having taken place. Spine horizontal and quadrangular, spine next above it having sloping upper edge. *Next lowest lumbar vertebra.* Transverse processes have triangular form and upward slope, but in less degree, which those of lowest lumbar vertebra usually present; narrower and a little shorter than those next above; pedicle thicker than usual for a next lowest lumbar vertebra. Lower articular processes nearly $\frac{1}{2}$ inch wider apart than superior. *Sixth lumbar vertebra* (24th vertebra). Transverse processes same length as those of 3rd and 4th; thick both ways, vertically $\frac{1}{2}$ inch thick, antero-posteriorly right 9, left 7 lines. Slant a little upwards; outer ends bluntly oblique, facing to sacrum but $\frac{1}{4}$ inch from it: pedicle has the usual thickness of a lowest lumbar vertebra. Lower articular processes $\frac{1}{8}$ inch less apart than the upper are. Distance between upper sixth $1\frac{7}{8}$ inch.

Sacrum 5 pieces. Breadth $4\frac{1}{4}$ inch, length in front, $3\frac{3}{4}$ straight, along curve $4\frac{1}{8}$, depth of curve 8 lines, curve mainly at lower half, beginning at middle of 3rd piece. Upper surface of wings less sloping than usual. Auricular surface reaches on right side to opposite middle, on left side to near lower edge, of 2nd foramen; upper part of that surface broader on right than on left side. Canal opens at 4th piece. No horn on left, short on right side. Outer boundary of 4th foramen $\frac{1}{3}$ inch broad on right side, on left mostly wanting. Lower end, $\frac{1}{2}$ inch transversely. *Coccyx* represented by the three nodular pieces, ankylosed together. Total length $\frac{7}{8}$ inch in front, behind $\frac{1}{8}$ inch more. First piece, length 4 to 5 lines, breadth 6 lines, tapering to 5; presents slight depressions on each side on a front view, but no line across, and no mark of any kind behind. Second piece, length 3 lines, breadth $5\frac{1}{2}$ lines, widest at middle. Third piece, length nearly 3 lines, breadth $4\frac{1}{2}$, termination semilunar.

The variation in this case presents some complexity. To which region is the suppression of the vertebra to be referred? The lumbo-sacral nerves would seem to indicate that the lowest lumbar vertebra is the usual 1st sacral set free, thus accounting for the seemingly deficient pelvic vertebra, and leaving 23 instead of 24 vertebrae above. The appearance of suppression of a vertebra in the neck, is met by the consideration that the 7th vertebra carries ribs, imperfectly developed on one side, like cervical ribs. Then, although only 11 ribs remain, the next vertebra below, though rib-less, has the normal articular processes of a 12th dorsal (19th vertebra). If it is to be regarded as such, and not as the 1st lumbar, then the suppressed vertebra would be really a lumbar, although there are six free vertebrae between the thorax and the pelvis. Whichever view be taken, this case is an interesting one, as exhibiting variation in every region of the spine, and as shewing the importance of examining the entire spine before deciding as to a variation of any one part of it. The observation of the grouping of the nerves along the whole spine, would always be important in these cases, but the dissection is generally far advanced before the variation of the vertebrae is noticed.

(c.) VARIATIONS OF THE 5th LUMBAR VERTEBRA. (1) *Examination of Cases illustrating the changes by which it becomes united to the Sacrum.* This union is by ossification at the parts which attach the inter-transverse (sacro-lumbar) ligament. The characters of the transverse process of the 5th lumbar vertebra which at once strike the eye, are, its greater thickness, tapering form, and upward slope. But a more remarkable character is the great antero-posterior thickness at its root, seen in a vertical view, making it appear to spring from the body as well as from the pedicle, as if a short rib had been consolidated here. The lumbar pedicles increase in thickness, antero-posteriorly, from above downwards, but that of the 5th is suddenly increased to about double that of the 4th. Beginning a little farther outwards at the canal, its attachment reaches obliquely forwards to near the middle of the side of the body, it may be even in front of the middle. This character is most conveniently referred to as increased thickness of the pedicle. The obliquity of the transverse process, as seen in front, is mainly on the lower edge, corresponding more or less to the similar slant of the neighbouring part of the sacrum. This margin presents, first, a concave part, the boundary of the intervertebral foramen, having generally a distinctly marked outer termination. Here the sacro-lumbar ligament begins, forming the outer boundary of the foramen. The outer more sloping part of the lower edge of the process is devoted to this ligament, the farther part of it, and also the tip, attaching the ilio-lumbar ligament. The lumbo-sacral ligament is attached, below, to the back part (transverse process part) of the wing of the sacrum; either to the developed upper angle and inwards from it, or, more inwardly, to the low conical process in which the back part of the wing may stop short. The distance between the transverse process and the sacrum varies a good deal; it is often $\frac{1}{4}$ inch, sometimes more, oftener less, often enough they are very near. They are brought together by lateral motion to that side and by extension, the ligaments of the opposite transverse process checking.

Specimens before me shew the process of sacralisation in various stages. In a female pelvis (case No. 8, sacral variation) the conical process (ascending inter-transverse process) rises up from the sacrum, so as to be almost in contact with the transverse process of the vertebra. In a male pelvis, aged 48, (case No. 9 of sacral variation) the sloping part of the transverse process is thickened downwards, and is within $\frac{1}{10}$ inch of the sacrum, for a breadth of $\frac{1}{2}$ to $\frac{3}{4}$ inch. In more advanced stages, the transverse process acquires much greater thickness, and bifurcates, the lower limb of the fork (descending inter-transverse process), passes downwards and outwards towards the sacrum, and articulates movably with the sacrum below, and, it may be, with the ilium externally. In a farther stage, the union may be broad and sutural; and, finally, osseous union takes place.

In the four cases to be related in which this vertebra appears to have been included in the sacrum (cases 1 to 4, sacral variation) the union is symmetrical, and the variation has probably been congenital. In the specimens before me, in which the vertebra has probably been at one time more normal, the approach, or union, is very unsymmetrical, or occurs on one side only. This condition is probably related to a lateral inclination of the spine.

1. Female aged 62 (case No. 5 of Thoracic variation. Ankylosed 12th ribs). *Left* transverse process massive and bifurcated, descending division articulating with sacrum. Height of process, at middle, 10 lines; each division as large as middle-sized finger; upper attached the ilio-lumbar ligament; lower articulates, below, for $\frac{3}{4}$ inch, by a synovial joint, with a concavity on outer part of sacrum, which has ascended a little to meet it. Lumbar process, together with the elevated part of sacrum, is received into a depression in the ilium, close above auricular surface, but the union is only ligamentous. Motion at the inter-transverse sacro-lumbar joint limited. *Right* side, simply a massive process. Height at middle, 9 lines; distance from sacrum $\frac{1}{4}$ inch. Lower articular processes $\frac{1}{4}$ inch wider apart than upper. Distance between upper $2\frac{1}{6}$ inch. Difference more marked on 4th.

2. Male aged 40 (case No. 11 of Sacral variation; 1st coccygeal united to sacrum). *Right* transverse process massive, height at middle, 10 lines; bifurcated; descending division as large as a thick finger, passes downwards and outwards, and articulates movably with a cavity on outer and back part of wing of sacrum, which ascends to meet it only on outer side, where they articulate with the ilium. Line of articulation between sacrum and transverse process, oblique, outwards and upwards from the foramen. Auricular surface reaches up to the very

top of sacral wing, and a little upon the lumbar transverse process; and down, on both sides, to near the lower edge of the 2nd normal foramen. Lower articular process on this side faces almost straight forwards; and lower processes $\frac{1}{8}$ inch less apart than the upper. Width between upper, 2 inches. *Left* side, transverse process shorter than usual, and as thick as little finger; corresponds to upper division of the bifurcated right process; distance from sacrum, 4 lines.

3. Female skeleton. Vertebrae C. 7, D. 12, L. 5, S. 5, C. lost. Same subject as case 7 (b) of ankylosed short cervical ribs. *Right* transverse process of 5th lumbar vertebra, massive. Height at foramen $\frac{3}{4}$ inch. Short thick wing, rather than a bifurcation; upper angle corresponds to transverse process of left side, but is thicker. Below, articulates broadly, for $1\frac{1}{4}$ inch, with outer and back part of sacral wing, which has risen up to meet it; articulation directed obliquely outwards and upwards, and movable. In growing towards each other, most in front has been done by the sacrum, most behind by the lumbar wing. Only a very small part of the latter appears to have articulated with the ilium. *Left* transverse process, thicker than usual externally; distance from sacrum, about $\frac{1}{4}$ inch. Lower articular processes $\frac{1}{4}$ inch nearer each other than the upper are. Distance between upper, 2 inches. Neither upper nor lower quite symmetrical. Those of 4th equidistant. Lower processes of 3rd are $\frac{1}{8}$ inch wider apart than upper, but not so wide as those of 4th.

4. Male aged 47 (case 4, Thoracic variation. Very unequal 12th ribs). *Right* transverse process massive, 1 inch in height at middle; expanded externally as a wing, nearly $1\frac{3}{4}$ in breadth, anterior surface looking obliquely forwards and upwards. Outer and lower part of wing ankylosed to outer and back part of wing of sacrum, which has ascended to meet it; line of ankylosis 1 inch in length, directed obliquely upwards and outwards from the foramen. Free outer edge of wing slopes upwards and inwards to a blunt upper angle; and, below, supports the upper end of the auricular surface. Upper portion of auricular surface, $1\frac{1}{2}$ inch in length, is prolonged on ascending process of sacrum, and for about $\frac{1}{3}$ inch on wing of lumbar vertebra; lower portion, somewhat shorter, reaches down to opposite lower edge

of 2nd normal foramen. The wing-like expansion of the lumbar transverse process here presented, is remarkably like that of the corresponding part of the first sacral vertebra in cases 1 to 4 of sacral variation, in which the 5th lumbar vertebra appears to have been sacralised. *Left* side, transverse process, shorter and somewhat thicker than usual, distance from sacrum $\frac{1}{4}$ inch. Lower articular processes $\frac{1}{3}$ inch wider apart than upper, and not symmetrical. Width between upper, $1\frac{3}{4}$ inch.

Reference may here be made to the condition of the lumbar transverse processes in cases Nos. 5, 6 and 7 of lumbar variation, shewing six lumbar vertebrae. Although we sometimes speak of that condition as one in which a sacral vertebra has been given off to the lumbar region, the condition is simply that the 25th vertebra has remained free. The cases therefore serve to illustrate the approach of a vertebra to the sacrum, and there is greater symmetry. In each of the three, the transverse processes are larger than usual, and articulate by facets with back part of wing of sacrum, in case 7 on both sides, in cases 5 and 6 on the side on which the process is larger than on the other; and in these two cases, the greater transverse process has an articular facet for the ilium also. Case No. 4 of lumbar variation illustrates still better the advancing sacro-lumbar synostosis[1].

[1] *Occurrence of this change in the Gorilla.* In the Gorilla, and apparently also in the Chimpanzee and the Orang, the lowest lumbar vertebra more or less frequently becomes united to the sacrum in old subjects. This change appears to be by some considered as normal, by others only as not unfrequent. In the specimen of the gorilla in my possession, that of an adult but not old male, this vertebra (the 24th) is quite free, and shews no indication of that change of form by which it would come to resemble an upper sacral vertebra. No doubt, the upward elongation of the iliac wings, and the closeness and ligamentous connection of the last rib to the iliac crest, with the related lesser mobility of the lumbo-sacral articulations, place the gorilla favourably for the occurrence of this synostosis with advancing age; but, comparing my specimen with that figured by Professor Owen (*Trans. Zool. Soc.* Vol. v. plate 12, fig. 2), in which the 24th vertebra has become the broadest piece of the sacrum, I have great difficulty in believing that this vertebra would in the farther life of this individual have undergone such a change. Between its short blunt transverse processes and the upper border of the first sacral vertebra, there is a triangular gap, internally 4 lines, externally 9 lines in height. The greatest breadth of the sacrum, at the brim-line, is $3\frac{1}{2}$ inches, contracting upwards to under $2\frac{3}{4}$ inches. The breadth of the lowest lumbar vertebra, from tip to tip of its transverse processes, is the same as that of the sacrum at its upper border, a line less than the $2\frac{3}{4}$ inches. The blunt outer ends of these transverse processes, $1\frac{1}{4}$ inch in height, by $\frac{3}{4}$ inch in breadth, are but from 2 to 3 lines distant from the corresponding shallow and smooth recess in the ilium. I have noted considerable variation in regard to the free or sacralised

(2) *Variation of the lower Articular Processes of the 5th Lumbar Vertebra.* The articular processes of the 5th lumbar vertebra present the double character of great actual width apart, as compared with those of the vertebrae above them, and of greater width apart of the lower compared with the upper processes; an adaptation to the greater breadth of the human sacrum. The first piece of the sacrum presents the contrast of having its lower articular processes much nearer each other than the upper processes are. But these characters of the articular processes of the 5th lumbar vertebra are not invariable, nor are they distinctive of a 5th as compared with a 4th lumbar vertebra. The increase in width apart of the lumbar articular processes begins generally on the 3rd, and becomes marked on the 4th. While the lower processes of the 1st and 2nd are nearer each other than the upper processes of the same vertebra, those of the 3rd may be as wide apart as its upper processes, or a little wider. The lower of the 4th are wider apart than the upper by about ¼ inch, or it may be less; and the lower of the 5th are wider apart than the upper by from ¼ to ½ inch. This is between the outer articular margins, but between the inner articular margins also shews the difference; which is not due to the processes having been turned round so that they face more forwards and backwards, but to actual carrying outward of the whole process, although the change of position and the change of direction are associated.

But while these differences are seen in a series, they will not serve to distinguish a 5th from a fourth, which presents the same characters absolutely, sometimes highly, while the 5th may shew them to a less than usual degree. Better characters are the thickness of pedicle, and the generally greater depth of

condition of this vertebra (the 24th) in the specimens of the gorilla in museums, and the differences may be referable to individual variation as well as to age; but the number of specimens altogether as yet in museums is not sufficient to afford ground for safe generalization on such a point. The cases of human variation above recorded, in which a 13th rib is developed, correspond in this respect to the normal condition in the gorilla and chimpanzee, except that the rib in them is more fully developed; while the cases of 5th lumbar vertebra uniting to the sacrum, correspond to what is at least a frequent if not the normal change in the anthropoids with advancing age. In man, however, the reverse change, that of leaving the 25th vertebra free, appears to be more common, tending to increase his lumbar region at the lower part; while the tendency in the gorilla is in the direction of decrease, by iliac as well as by costal encroachment.

the body before than behind. Farther, in some instances the lower processes of the 5th may not be so wide apart as the upper, though I have not met with a fourth in which it is so. 1. In one case (case No. 3 of imperfectly developed 12th ribs, and also case No. 5 of cervical rib; female), the lower articular processes of the 5th lumbar vertebra are exactly the same distance apart as the upper processes, while the lower processes of the 4th are $\frac{1}{8}$ inch farther apart than the upper. The lumbo-sacral processes are very little turned round, so that the sacral processes face very much inwards. 2. In another case, a detached 5th lumbar vertebra, the lower and upper processes are equidistant; the lower processes have the same inward direction as in the last case, but to a less degree. 3. Reference is made to other cases in the following summary.

Summary of the disposition of the articular processes in the cases in which the lowest lumbar vertebra is variously abnormal. It will be seen to be very various, appearing as if determined sometimes by functional circumstances, sometimes by the inherited character of individual vertebrae. In the four cases (variation of 5th lumbar vertebra) in which the 5th lumbar transverse process was articulated or ankylosed to the sacrum on one side, the lower articular processes of the 5th are wider apart than the upper in two (cases 1 and 4), and not so wide apart as the upper in two (cases 2 and 3). In the three cases of movable sixth lumbar vertebra (lumbar variation, cases 5, 6, and 7); in case No. 5, lower processes of sixth not so wide apart as upper; those of fifth $\frac{1}{4}$ inch wider apart than lower, and wide. In case No. 6, lower and upper processes of sixth equidistant: lower of fifth a little wider apart than upper, but not wide. In case No. 7, processes not wide apart; lower of sixth $\frac{1}{4}$ inch more apart than upper; lower of fifth $\frac{1}{8}$ inch more apart than upper. In case No. 3 (lumbar variation), also with movable 25th vertebra, lower processes both of sixth and of fifth are $\frac{1}{4}$ inch wider apart than their upper processes, but are not wide apart and look much inwards. In case No. 9 (lumbar variation), in which the sixth lumbar is the 24th vertebra actually, and freely movable, the lower articular processes are $\frac{1}{8}$ inch less apart than the upper; while the lower of the vertebra next above are $\frac{1}{8}$ inch more apart than the upper. In the cases in which a lumbar vertebra appears to have been ankylosed to the sacrum (cases 1 to 4, sacral variation), the lower articular processes on the first sacral piece have the usual inward sacral position, compared with the upper processes. In case No. 1 of these, in which alone the movable vertebrae were present, the lowest lumbar (23rd vertebra) has the lower articular processes ½ inch wider apart than the upper, and wide. In case No. 4 (lumbar variation) in which the sixth lumbar (25th) vertebra is partly ankylosed to the sacrum, the lower processes of that vertebra are ½ inch nearer each other than the upper, which are wide (2¼ inches apart); while the lower of the fifth are ¼ inch wider apart than the upper.

(3) *Variations of the upper Articular Processes of the Sacrum.* These processes vary frequently in direction, curvature, and size. It may be remarked that they usually face more backwards than the upper lumbar processes do. This sometimes goes so far that the sacral processes face almost directly backwards. Sometimes they are much more concave than the lumbar processes; in other cases almost flat, as when they face much backwards; but the curve is generally greatest at the inner and fore part. When flat, and facing but little inwards, they are mostly small; the much curved ones mostly large. Want of symmetry is not uncommon, both as to curvature and general direction. The variations of these processes indicate corresponding variations of the lower articular processes of the 5th lumbar vertebra, in addition to the varieties in width apart above noticed, but they are more easily studied on the sacrum.

(D) Variations of the Sacrum.

(a) Diminution in the number of Vertebrae composing the Sacrum. This condition is rare compared with the opposite one of increase. In case No. 6 (lumbar variation) we had an instance of a sacrum with only 4 vertebrae, in which there were 6 lumbar vertebrae, and 4 coccygeal. In that case the diminution was accounted for by the upper vertebra remaining free; in the following case the diminution appears to have been due to the lower vertebra remaining free.

Second case of adult sacrum composed of only 4 vertebrae. A fully ossified but small pelvis, the upper pelvis especially unexpanded, having on the whole the characters of the male more than of the female pelvis; upper parts of thigh-bones, which are present, muscular and shew very oblique neck. Sacrum normal above, as also the lowest lumbar vertebra, which is present. Only the first vertebra below the 4th sacral is present, the rest being lost. This piece is quite movable; body very short, 3 to 4 lines, and broad. Breadth where it articulates with sacrum, 10 lines, and concave transversely; lower end 6 lines transversely. Wings slender, especially left; these and left horn in contact with sacrum but not ankylosed. No distal horn. The form of this piece might pass it for either a 5th sacral or a 1st coccygeal. There may not unlikely have been 4 coccygeal pieces beyond, but, while the sacrum normally consolidates from below upwards, we have here what would have been the 5th piece remaining quite free, leaving a sacrum with 4 pieces. Canal opens at lower part of 2nd piece. Auricular surface goes down to opposite lower edge of second foramen. Breadth of sacrum almost 4 inches; length, in front, $3\frac{3}{8}$ straight (with movable piece $\frac{1}{6}$ inch more), along curve $3\frac{5}{8}$ (with movable piece $\frac{3}{8}$ more); depth of curve 6 lines (with movable piece 8 lines).

(b) Examination of Cases of variation in form of the upper Sacral Vertebra, in which it appears to be the lower lumbar vertebra added to the sacrum. The Ape-like sacrum. Case 1. For a case in which the upper sacral vertebra must be considered as obtained from the lumbar region, from its peculiar form together with the absence of a dorso-lumbar vertebra, reference is made to case No. 8 under lumbar variation. The account of the form of the 1st sacral piece is specially referred to.

Case 2. *Wings of 1st sacral vertebra very deficient in front; sacrum of 5 pieces.* In a well-marked male pelvis. Brim-line of true pelvis is on 2nd piece. Brim-line of ilium bifurcates, the lower runs on 2nd piece of sacrum, the upper runs to 1st piece. Body of 1st inclined a little back from curve of sacrum. Upper surface of wings slopes very much forwards, beginning at lower edge of 1st foramen, especially on left side. Greatest breadth of 1st piece, at upper end of auricular surface, 4⅝ inches; of 2nd piece, at brim-line, ¼ inch less. But to the eye the first piece seems as if narrower than the 2nd, owing partly to the want of the usual much greater breadth of the 1st piece, partly to the first piece rapidly narrowing above the auricular surface. Neck of wing, as seen in front, considerably thinner than that of 2nd, which is unusually robust (9 to 10 lines) and like that of a first sacral piece. Even as seen obliquely, from above, the breadth of neck of wing of 1st piece is not equal to either the vertical or the antero-posterior measurement of neck of 2nd piece. Is ossified to 2nd by the wings only, a fissure still remaining at outer side of left foramen. Second not quite ossified to 3rd at body, or on right side. Traces of epiphyses of iliac crests still visible. Auricular surface reaches from middle of 1st piece down to opposite the upper ⅔ of the 3rd foramen. Canal opens at 4th piece. Fifth piece resembles an ordinary 4th; breadth between tips of wings 2½ inches; horns robust; lower end, breadth 1 inch, cartilaginous surface transversely convex and not much bevelled. Remainder lost. In this case the sacrum has only 5 pieces, while in case 1, and in the two following cases, it has 6.

Case 3. *Wings of 1st sacral vertebra very deficient in front; sacrum of 6 pieces.* Upper sacral vertebra closely resembling that of last case, but sacrum smaller and not quite fully ossified. Is ankylosed only by inner half of wings, as seen in front. the entire wing not yet ankylosed behind. Body inclined a little back from curve of sacrum. Wings slope much forwards, the slope beginning at outer edge of foramen. Greatest breadth, at upper end of auricular surface, 3⅝; of second piece, at angle of auricular surface, ⅛ inch less. Neck of wing, as seen in front view, is much thinner than that of 2nd, which is robust (7 lines) and convex, liker that of a first, for a sacrum of this size. Seen obliquely, as from above, the breadth is scarcely more than either the vertical or the antero-posterior measurement of the 2nd. Rounded off brim-line runs in on 2nd piece. Auricular surface; angle at middle of 2nd piece; upper portion goes up at very obtuse angle to lower and anterior third of 1st piece; goes down as far as rather below middle of 3rd foramen, but apparently not reaching across the remains of the fissure between the 3rd and 4th pieces. Sixth piece ossified to 5th by horns and wings but not by body, no distal horns. Lower end 5 to 6 lines transversely. But for the peculiarities of the upper piece, this sixth piece might pass either as a fifth sacral, or as an ankylosed 1st coccygeal. Coccyx lost.

Case 4. *Sacrum very like the last, but large.* Upper vertebra ankylosed by whole of wings and side parts of body. Body and wings same characters as in last two cases. Breadth of 1st piece $4\frac{7}{8}$, of second $\frac{1}{8}$ less. Auricular surface, upper portion goes off at very obtuse angle, extending on 1st piece for an inch; angle is on wing of 2nd piece; lower portion goes down to rather below middle of 3rd foramen. Brim-line is on 2nd piece, but very much rounded off. First foramen, as in last case longest vertically, and is smaller in this case than the 2nd or 3rd foramen. Fourth foramen as small as 5th, and much smaller than 3rd. Sixth sacral piece united by wings, not by horns or most of body. Canal opens at 4th piece. No distal horns. Lower end 6 to 7 lines transversely.

In the absence of the vertebrae above and below, there can be no absolute certainty; but in these three last cases, as well as in the first case, the lowest lumbar vertebra appears to have been sacralised; the characters, indeed, being in all the three, more marked than in case No. 1 in which the deficiency of a dorso-lumbar vertebra is proved. The sacralisation in case 1 is carried so far that the upper piece attains the usual predominating breadth over the 2nd, and supports not merely the upper portion of the auricular surface, but also the angle of that surface, together with the brim-line, which the position of the angle determines. In case 1, there is also little or no deficiency in the expansion of the back part of the wing, behind the auricular surface. As a result of this deficiency in cases 2, 3, and 4, the posterior angle of the wing is placed far in, rising as a conical process, towards which the side of the wing, behind the auricular surface, slopes rapidly inwards. In case 1, however, as in the others, the upper end of the auricular surface is, as in the normal sacrum, the broadest part.

Reference may be made here to the account of the condition of the lowest lumbar vertebra in case No. 4 of lumbar variation. Comparing the specimens, it is seen that a little more advanced ossification would have converted that vertebra into an upper sacral piece, similar to that in this group of cases. It is seen also, that the low conical process on the upper sacral piece corresponds to the upper limb of the bifurcated lumbar transverse process, and is the end of the true transverse process. In an otherwise normal 1st sacral piece, this process is the end of the unexpanded transverse process part of the wing.

(c) EXAMINATION OF CASES OF SACRUM WITH 6 VERTEBRAE, IN WHICH THE UPPER IS OF UNUSUAL FORM, BUT IN ALL OF WHICH THE ADDITIONAL PIECE APPEARS TO HAVE BEEN GAINED AT THE COCCYGEAL END. Cases 5 and 6. In these two sacra, the wings of the upper piece have a marked downward and outward direction and are deficient in thickness. Case 5. A robust sacrum. First piece entirely ossified to 2nd, and body continues the curve of the sacrum, but wing is modified. Is deficient in thickness, so that, seen in a strictly front view, neck is considerably thinner than that of 2nd piece, while 2nd is not much more robust than usual. Direction is obliquely downwards and outwards, giving a very oblique brim-line, a little above the 1st foramen, and placing the auricular surface so low that its upper part is rather below the level of the upper edge of the 1st foramen. Wing deficient also at upper and outer part, so that upper part of auricular surface is very short. The conical process (ascending inter-transverse process) which often rises from some part of the posterior margin of the wing, and is well seen also in the next case, is here close to the articular process, and rises as high as it. Antero-posterior measurement of wing external to this, at middle, 1 inch; expanding outwards to only $1\frac{1}{4}$. Breadth of 1st piece $4\frac{7}{8}$, of second $4\frac{1}{8}$. Auricular surface reaches down to opposite upper edge of 3rd foramen. Canal opens at 5th piece. Coccyx present; 3rd and 4th pieces ankylosed; 2nd separate, and of usual form; 1st has evidently furnished the 6th vertebra to the sacrum. Fifth foramen, and union of the right horns, incomplete.

Case 6. A well-marked female pelvis, very capacious, and somewhat twisted to left side in front. Body and wing of 1st sacral vertebra as in last case, but wing not so deficient in expansion at upper part of sacro-iliac articulation. In strictly front view, neck not thicker than that of 2nd piece, which is not unusually robust. Brim-line passes obliquely upwards to promontory, a little above 1st foramen, above the plane of the rest of the pelvic brim. Breadth of 1st piece $4\frac{5}{8}$, of 2nd piece $3\frac{4}{8}$. Auricular surface reaches down to opposite upper edge of 3rd foramen. First foramen, as in last case, unusually large, especially in vertical direction. Canal opens at 4th piece. Sixth piece appears to be the 1st coccygeal, ankylosed by body and left horns; has short wings, above which are widely open notches; lower end 5 to 6 lines transversely. Rest of coccyx lost.

Although the want of thickness, and the lateral slope, of the wings, in these two cases, is sufficiently marked to attract notice, this condition is not to be confounded with that presented by the preceding four cases, in which the fore part of the wing (that where a true sacral vertebra is developed from a rib) is undeveloped, giving the ape-like form to the upper sacrum.

Cases 7 and 8. In these two cases, both well-marked specimens of female pelvis, the downward direction of the wing is seen in a less degree, but there is no deficiency in breadth of wing externally, and the neck, as seen in front, is somewhat thicker than the neck of the 2nd vertebra. Breadth of 1st piece in each, $4\frac{7}{8}$ inch; of 2nd piece, 1 inch less. In one (No. 7) the three nodular pieces of the coccyx are present, the first piece ankylosed to the sacrum and forming its 6th piece. Sacro-iliac articulation goes down to nearly opposite upper part of 3rd foramen. In the other (No. 8) the two distal pieces of coccyx are broken off, leaving one with the usual characters of the third piece, and the first piece ankylosed to the sacrum by body and right horns. Wings of latter transverse, leaving 5th foramen as a wide notch. Sacro-iliac articulation goes down to opposite nearly the middle of 3rd foramen.

Cases 9 and 10. Two well-marked male pelves. Wings of 1st sacral vertebra, though massive enough, attract notice as having more downward and outward slope, and also more forward slope, than usual; giving a brim-line more oblique, and less distinct, than usual. In one (No. 9) a male aged 48; breadth of first piece $4\frac{6}{8}$ inch, of second $3\frac{5}{8}$. Sacro-iliac articulation reaches down to opposite rather below upper edge of 3rd foramen. Coccyx, 3rd and 4th pieces partially ankylosed; 2nd free; 1st completely ankylosed to sacrum, by body wings and horns. It has no distal horns but abrupt eminences, and 2nd piece has minute proximal horns and commencing transverse processes. In the other (No. 10) a male aged 30; breadth of first piece $4\frac{7}{8}$ inches, of second piece 4. Sacro-iliac articulation goes down to opposite upper $\frac{1}{3}$ or $\frac{1}{4}$ of third foramen. First coccygeal piece ankylosed to sacrum by wings, imperfectly by body, horns in contact. Second piece has minute horns and commencing wings, and is free. Third piece, a triangular nodule, also free. Fourth piece wanting and has, apparently, been lost.

(d) Examination of other cases of Sacrum composed of 6 Vertebrae, by addition of the first Coccygeal. Case 11. Male aged 40. Coccyx, three distal pieces, all separate, and nodular. First piece, wings and horns short, is partly ossified to sacrum by body, forming the 6th piece of sacrum. Canal opens at lower part of 4th piece. Right transverse process of last lumbar vertebra large, bifurcated, and articulates with sacrum (see case 2 of variation of 5th lumbar vertebra).

Case 12. Male aged 34. First coccygeal ossified to sacrum, by right wing and right side of body; left 5th foramen widely open; horns do not meet. Rest of coccyx one ankylosed mass, with constrictions which might be held to indicate either 3 or 4 pieces, without any processes. Canal opens at lower edge of 4th sacral piece. Auricular surface reaches down to nearly upper edge of 3rd foramen.

Case 13. Well-marked male pelvis. Three distal pieces of coccyx ankylosed to each other. First piece ossified to sacrum by body and horns; wings transverse, leaving 5th foramina as wide open notches. Auricular surface goes down, on left side, to opposite middle of 3rd foramen; on right side, not quite so far.

Case 14. Female skeleton; adult but of short stature. First coccygeal vertebra, united to sacrum by body, wings, and horns. Nodular pieces of coccyx ankylosed into one bone, with 3 constrictions; doubtful whether this coccyx has 5 pieces, or a 4th with hour-glass contraction. Canal opens at lower part of 4th sacral piece. Auricular surface reaches down to near upper edge of 3rd foramen.

Case 15. Female pelvis. Traces of epiphyses still visible. First coccygeal vertebra ossified to sacrum by right horns; motion at left horns and at body. Wings short, and 5th foramina very wide notches. Rest of coccyx lost. Canal opens at 5th piece. Auricular surface reaches down to opposite upper $\frac{3}{4}$ of 2nd foramen, but a fissure of development, still remaining, distinctly shews that the ilium is $\frac{1}{8}$ inch from touching the 3rd sacral vertebra.

Case 16. Female pelvis. Aged 32. A sixth vertebra united by body, wings, and horns to sacrum. Rest of coccyx lost. Canal opens on 5th piece. Auricular surface goes down to lower edge of 2nd foramen.

Case 17. Fully ossified but small pelvis. Sex uncertain. Same as last case, but left horns not united, and wings not so broad. Canal opens on 5th piece. Auricular surface goes down to rather below upper edge of 3rd foramen.

(e) Variation in the number of Sacral Vertebrae with which the Ilium articulates. *Development of the parts which support the auricular surface.* It is evident enough in young sacra, that the upper piece forms much the largest part of the foramen, but specimens in which consolidation is nearly completed shew the line more precisely. The part next the foramen has consolidated first, and the fissure passes outwards opposite a little above the lower edge of the foramen, undulating, but on the whole horizontally, whether seen before or behind; and opens externally, the edges curving upwards and downwards. Upon the upward and outward projection thus formed by the shoulder of the 3rd vertebra, the lowest part of the ilium rests; the cartilage, or bone, of the lateral epiphysis intervening here, as well as higher up, in the unfinished bone. Taking the limits of the anterior foramen proper, from a third to a fourth, or less, of the foramen is formed by the 3rd vertebra; but the outer part of the fissure may be quite down to the level of the lower edge of the foramen. If, therefore, the auricular surface does not pass below the middle of the 2nd foramen, we may conclude that the ilium has not rested on the 3rd vertebra; and that, unless it has passed down to nearly opposite the lower edge of the foramen, there is uncertainty whether it has reached upon the third. Young specimens farther shew that the sacral ribs have expanded so much, antero-posteriorly, at their outer part, that they form much the greater part, about $\frac{3}{4}$, of the breadth of the lateral surface, supporting the whole auricular surface and part of the ligamentous surface behind it.

Varying extent of auricular surface. Cases in which it rests on only two vertebrae. A projection, seen in a front view, forming a mid-lateral angle, indicates generally the lower end of the auricular surface, but careful inspection is required, in front and behind, before concluding as to the true level in relation to the foramen. It will then be found that the extent to which the articulation passes down upon the 3rd vertebra varies considerably, and that sometimes it rests only on the 1st and 2nd vertebrae. The latter condition appears to occur more frequently in the female than in the male. In 20 specimens of sacrum composed (with one exception, a male) of 5 pieces, in which the sex is certain, 12 female, 9 male, the position of the lower end of the auricular surface is as follows. In the twelve *female* specimens, it does not reach to the third vertebra in four, and probably in a fifth; it reaches on the third vertebra certainly in two, probably in other two, while in one it probably does so on one side and probably not on the other; in the remaining two it is uncertain. In one of those in which it rests on two vertebrae only, (a characteristic and wide female pelvis, sacrum much curved,) it reaches only to the upper edge of the 2nd foramen; and in another (sacrum very little curved) to the middle of the 2nd foramen. In none of the twelve does it go down farther than just a little below the lower edge of the 2nd foramen. In the 9 *male* specimens, it goes down upon the 3rd vertebra in 7; in one (with remarkably wide upper pelvis) it is doubtful, probably touching the 3rd on one side only; and in the ninth (a robust middle-sized skeleton, case No. 1 of ten sacro-coccygeal vertebrae) it is not lower than the upper two-thirds of the 2nd foramen, and does not appear to have touched the 3rd vertebra. In most of the seven, it goes well upon the 3rd, the farthest being to a little below the upper edge of the 3rd foramen. In one, an adolescent specimen, in which it goes to midway between the 2nd and 3rd foramina, it is seen to rest for $\frac{1}{4}$ inch upon the third vertebra.

Position of the auricular surface in the cases of abnormal sacrum. In the cases of more or less abnormal sacrum above noted, the position of the auricular surface is mentioned with each. In the third group ((d) cases 11 to 17, each of six pieces, the sixth obtained from the coccyx) it extended upon the third vertebra freely in two of the males (12 and 13), and probably in the third (11), and freely in the specimen (17) of uncertain sex. In the three female specimens, certainly in one (14), probably in one (16); and in the third (15) though reaching opposite $\frac{2}{3}$ of the 2nd foramen, the fissure shews that it does not reach the 3rd vertebra. In the second group ((c) cases 5 to 10, sacra of 6 pieces, upper piece more or less abnormal, but 6th piece obtained from coccyx) it reaches on the third vertebra freely in all, including three female specimens; in one, reaching nearly to the upper edge of the 3rd foramen, in the other five, reaching farther down. In the first group ((b) cases 1 to 4, in which upper vertebra appears to be 5th lumbar added to sacrum), the auricular surface rests on three vertebrae, being the borrowed vertebra and the two upper true sacral vertebrae. In one (case 2) it reaches down to very near the 4th piece.

In the five cases of a dorso-lumbar vertebra more than usual (lumbar variation, cases 3, 4, 5, 6, 7) the ilium articulated with the vertebrae as follows. In case No. 5, with the sixth lumbar vertebra on both sides, by a small facet, largest on the right side; with the sacrum, on right side apparently with two, on the left side apparently with three of its five vertebrae. In case No. 6, with the sixth lumbar vertebra on right side; with the sacrum, on right side with two, on left side apparently with three of its four vertebrae. In case No. 7, ilium does not touch the sixth lumbar vertebra; articulates with upper two of the five sacral vertebrae, and apparently only by ligament with the third. In case No. 4, in which lowest lumbar is partly sacralised, ilium rests on small part of sixth lumbar on right side, an ascending process of sacrum intervening on left; and on two of the five sacral vertebrae on each side. In case No. 3, ilium not in contact with transverse processes of sixth lumbar it rests on three of the five sacral vertebrae.

(f) Variation in the form of the auricular surface. On examining a series of innominate bones and sacra, the bend of the sacro-iliac articular surface is seen to vary much; sometimes it is very obtuse, sometimes rectangular or less. This is determined by two distinct conditions, the conjunction of which may give either form in an exaggerated degree. Less complete development of the fore part of the wing of the first sacral vertebra, giving obliquity to the portion above the angle; and little curvature of the sacrum, influencing the direction of the part below the bend, together contribute to the obtuse-angled variety, strongly marked in the ape-like sacrum. The opposite conditions determine the rectangular variety. Want of symmetry, as to breadth, and as to longitudinal extent, up or down, is occasionally seen.

(g) Case in which the Sacral Canal is open in its whole length. Sacrum of 5 pieces; otherwise well formed, and well ossified, but line of union between bodies of 1st and 2nd pieces is open at middle in front, and same between 3rd and 4th, and 4th and 5th, pieces on posterior aspect. Laminae about ½ inch from meeting; form a continuous smooth plate on each side internal to posterior foramina which ends in a smooth nearly straight margin. Slight projections at the edge at the 1st and 2nd vertebrae; narrowest part is at 2nd, gap widening a little upwards and downwards. Edges run up into inner side of articular processes, down into horns of moderate length.

(E) Variation of the Coccyx.

(a) Diminution in the number of the Coccygeal Vertebrae. Instances of the movable coccyx composed of only

3 pieces are of no value as bearing on the question of absolute numerical variation, unless there is present at least a well-formed sacrum of five pieces, including a well-formed upper sacral piece. Even then the seemingly suppressed vertebra may be found as a sixth lumbar, as we saw in case No. 5, of lumbar variation. Case No. 9 of the same group, shews 3 coccygeal with 5 sacral, yet the nerves seemed to indicate that the suppressed vertebra was from higher up. But, considered as a regional fact, cases of the movable coccyx composed of only 3 pieces are common; and considered as a serial variation, cases of 3 coccygeal pieces along with 5 sacral occur occasionally (as in cases Nos. 5 and 9 of lumbar variation) while cases of 3 coccygeal with 6 sacral, the upper sacral not borrowed, are common, as in the seven instances in the third group of cases (Nos. 11 to 17 of sacral variation), and apparently also in the six cases in the second group (cases Nos. 5 to 10).

(b) INCREASE IN THE NUMBER OF THE COCCYGEAL VERTEBRAE. *Remarks on sources of fallacy.* Cases may occur in which the 5th sacral vertebra instead of consolidating first, has remained separate, of which the case of a sacrum with only 4 pieces, given under sacral variation ((*a*) second case), is an example; and probably also case No. 2 (*b*), although the sacrum had 5 pieces. In such cases the apparent coccyx may have had 5 pieces, but in these two cases the coccyx had been lost. But it is in my experience rare to find the coccyx presenting five pieces, besides the five sacral pieces. The first piece is easily enough recognised, either separate or ankylosed to the sacrum, but sometimes the nodular pieces are so united that no reliable conclusion can be drawn as to how many pieces there had been. Putting aside such specimens, there remain others in which it is not easy to decide how far a kind of constriction which is sometimes seen on the 4th, is to be accepted as evidence of a 5th having existed. But after the study of a series of well-formed specimens of coccyx in various stages of ankylosis, it becomes in most cases easy to recognise where a union has taken place, the examination being made on both aspects and by the help of a magnifying power. Besides the lateral notches, a groove runs across before and behind, and is sometimes quite distinct on one aspect when it is obscure on the other, generally most distinct on the dorsal aspect. Of the three distal pieces, the 3rd and 4th are found united when the 2nd is still free; and in cases in which the three distal are united, the constriction between the 3rd and 4th is the least marked.

Forms presented by the respective coccygeal vertebrae. The *first* piece, either separate or united to the sacrum, has almost always more or less developed horns and wings. The *second* is generally bluntly triangular, and generally broader than long. In cases Nos. 9 and 10 of sacral variation, males aged 48 and 30, in which the first coccygeal piece is sacralised, the second, (the first free piece,) presents short wings and slight ascending horns, and is intermediate in size and form between the usual first and second coccygeal. The *third* is usually square-shaped, with rounded angles, and may also be broader than long. The *fourth* is of various forms; may be broader than long, may diminish to a blunt point, or to a very slight bifurcation, or may have a semilunar termination somewhat like the end of a digital phalanx; or it may be longer than usual, and present the appearance of a constriction. In some instances the form of this hour-glass 4th piece appears to result only from a semilunar expansion at the end, the constriction wanting that regularity and smoothness which generally characterise the groove between two united pieces; while in other specimens the indication of separation between a third and fourth has not greater distinctness. Section does not appear to help. In two specimens before me of section of normal sacrum and coccyx, in which the three nodular pieces of the coccyx are ankylosed but plainly indicated externally, the cancellous tissue of the three nodular pieces has become continuous, at least at the centre. It is not that there is reason to doubt the probability or the fact of the occurrence of a true additional coccygeal vertebra, but I desire to caution the observer against being too easily satisfied with appearances on this score. Putting aside all such doubtful cases, the following are two instances of the occurrence of ten pelvic vertebrae.

1. *Case in which there are ten Sacro-Coccygeal Vertebrae, in addition to the full number in other regions of the spine.*

Male skeleton, fully ossified, middle-sized, and of good muscularity. Fifth sacral piece normal except that body is shorter, reaching only $\frac{1}{3}$ to $\frac{1}{2}$ inch, instead of $\frac{3}{4}$ inch, below level of lower edge of 4th foramina. *Sixth* piece partially ankylosed here; separate behind and at right side, ankylosed in front and at left side, but line visible. Breadth at junction with 5th piece $1\frac{1}{2}$ inch, at distal end $\frac{3}{4}$ inch, edges curving upwards and outwards from lower to upper end. No wings or horns from either this or next piece, but 5th sacral piece sends downwards strong horns, passing a little beyond the line of union between the bodies of the 5th and 6th pieces. Owing to shortness of 5th sacral body, and absence of wings from 6th, the lower lateral angles of sacrum project abruptly, and there is no attempt to enclose a 5th foramen. At a more advanced age there would probably have been little or no trace of a sixth piece having existed here. *Seventh* piece, movable on 6th; triangular; length 4 lines; breadth, 9 lines above, 6 lines below. Small tubercle on left side where a horn would grow. Eighth, ninth, and tenth pieces ankylosed to each other, and partially also to the seventh, with very distinct notches and grooves of separation, ankylosis of the two distal most advanced. Length of each of the three last, 3 lines. Breadths as follows; of eighth piece, 7 lines at upper part, diminishing to 5; of ninth piece, 5 lines, a little more above, a little less at lower end; tenth piece, 4 lines at middle, diminishing a little to a rounded termination. Total length of the five pieces, 19 lines; of the last four pieces 13 lines.

2. *Another case in which there are ten Sacro-Coccygeal Vertebrae.* Female aged 53. Six pieces ankylosed in sacrum, 7th piece free, 8th, 9th, and 10th ankylosed together. Sixth piece ankylosed to fifth by body and by robust horns, wings very short, forming lower end of notch instead of 5th foramen. Seventh piece, no horns or wings; length, 4 lines in front, 6 lines behind; breadth, 9 lines above, 6 lines at lower end. Length of the three distal pieces together, 9 lines behind, 7 lines in front; lengths of each separately, on dorsal aspect, eighth piece 4 lines, ninth and tenth pieces each $2\frac{1}{2}$ lines. Breadths at middle, of eighth piece, 5 lines; of ninth, 4 lines; of tenth,

3 lines, diminishing a little to a rounded end. Total length of the four distal pieces, 15 lines; including the sixth piece, 20 lines in front, 24 lines behind. Constrictions between the three distal pieces not nearly so well marked as in last case, but are sufficient. The ankylosis of the first piece to the sacrum is also more complete in this case.

(c) ORDER OF UNION OF THE COCCYGEAL VERTEBRAE. EXTERNAL INFLUENCES. The usual order of union of the coccygeal pieces, according to my observation, is first between the 4th and 3rd, next between the 3rd and 2nd, while the 1st remains separate or unites with the sacrum. The three distal pieces, more or less ankylosed, form one body moving freely on the first, and it is this probably which most commonly passes for the coccyx in practice. They are commonly said to be later in uniting in the female than in the male. In a specimen from a female aged 43, the 5 sacral and 4 coccygeal vertebrae are already all united into one bone, but there are traces of bony excrescence at various parts of the sacrum. Besides the influence of sex and of natural variability, the sedentary and other habits of the individual, must, especially in civilised life, influence the length of time during which the coccyx retains its mobility. In persons who sit while working, and in those who are much in the saddle or in the carriage, the coccyx must be kept in frequent passive motion; while in the recumbent posture it is freed both from external influences and from muscular traction.

ON THE DEVELOPMENT OF THE POWERS OF THOUGHT IN VERTEBRATE ANIMALS IN CONNECTION WITH THE DEVELOPMENT OF THEIR BRAIN. By JAMES BYRNE, *Dean of Clonfert, and Ex-Fellow of Trinity College, Dublin.*

ALTHOUGH Mind can never be identified with Matter, nor the acts and states of the mind reduced to acts and states of the brain, yet as the latter are the physical antecedents of the former, the study of the one class of phenomena is calculated to give light and guidance in the study of the other. The object of the present paper is to consider some general outlines of the development of the powers of thought in Vertebrate Animals in connection with the development of their brain, in the hope that such a general view may throw some light, both on the powers of the mind and on the functions of the brain.

An obvious characteristic of mental action in the lower animals as compared with the higher is, that it is to so large an extent instinctive. Now the nature of such instinctive action as involves thought may be well studied in the case of the Beaver, though his mental action is not limited to instincts. The following is an instructive account given by Mr Broderip of one which he kept in his house. I quote it from Dr Carpenter's work on *Mental Physiology*, p. 92.

"The building instinct shewed itself immediately it was let out of its cage and materials were placed in its way; and this before it had been a week in its new quarters. Its strength even before it was half grown was great. It would drag along a large sweeping-brush or a warming-pan, grasping the handle with its teeth, so that the load came over its shoulder, and advancing in an oblique direction till it arrived at the point where it wished to place it. The long and large materials were always taken first and two of the longest were generally laid crosswise, with one of the ends of each touching the wall, and the other end projecting out into the room. The area formed by the cross-brushes and the wall he would fill up with hand-brushes, rush-baskets, boots, books, sticks, cloths, dried turf, or anything portable. As the work grew high he supported himself on his tail, which propped him up admirably; and he would often, after laying on one of his building materials, sit up over against it, appearing to consider his work, or, as the country people say, 'judge it.' This pause was sometimes followed by changing the position of the material 'judged,' and sometimes it was left in its place. After he had piled up his materials in one part of the room (for he generally chose the same place), he proceeded to wall up the space between the feet of a chest of drawers, which stood at a little distance from it, high enough on its legs to make the bottom a roof for him, using for this purpose dried turf and sticks, which he laid very even, and filling up the interstices with bits of coal, hay, cloth, or anything he could pick up. This last place he seemed to appropriate for his dwelling; the former work seemed to be intended for a dam."

Here we see that though the labours of the Beaver in its natural condition seem to be full of purpose and guided by a wonderfully intelligent reference to the end which they are to serve, the animal is really urged to form its constructions by an impulse which is quite irrespective of that end and purpose. Mr Broderip's beaver can hardly have had any idea of a dam acting as such, connected with its successive acts of construction, and guiding those acts as what they were to realise; for its surroundings were inconsistent with such an idea. And if its successive acts were not quite independent of such an idea they would not have been performed under the circumstances. At the same time, however, the labours of the Beaver were far from being destitute of thought. On the contrary, it seems to have had a very distinct idea of the particular step of construction in which it was engaged, and to have been careful to make its work conform to that idea. Each constructive act was in continuation of what had been already done, and its regulative idea was suggested by the then state of the work. But the realisation of each such idea was sought in succession as an end, without reference to the ultimate result of the entire series of actions.

In our own mental constitution we are familiar with a process by which means come to be sought for themselves without reference to the end which they subserve; the desire having been transferred from the end which was originally its object to the means which have been successfully used for the attainment of that end. The money which was first prized only for what it could purchase comes gradually to be desired for itself, and is sometimes preferred to any thing that it could buy, the means having become the end, and the original end being comparatively disregarded. And in truth many, if not most of the objects which we seek in mature life, are examples of desire similarly transferred. In such cases the means successfully used to attain the object of our desire become associated in the mind with the pleasure of that attainment, so that a sense of such gratification combines with the thought of those means, and forms part of the idea of them; and in proportion as this takes place the means attract to themselves the desire, and are sought as an end. When a variety of ends are attained by similar means, as when money is found to purchase all other commodities, then a corresponding variety of desires become combined with the idea of those means, and the compound attractiveness which they thus acquire is different from any of the original desires, and may supplant them all. But when the same means continue to be used only for the attainment of the same end, it is the gratification of the original desire which is combined with them, and this desire, after having sought the means, goes on to seek the end. A succession of means may in this way come to be sought, each one attracting action after the other, and leading to the attainment of the original end. And if this process be often repeated it will become habitual, and may even be transmitted to offspring as an hereditary tendency, so as to generate an instinct; though there are some instincts which could not have been originated in this way. Now in human nature, according as such series of acts become more and more habitual and easy, they are performed with less and less thought, till at length they may be performed without any thought at all, being guided only by sensation. But when they do engage thought, that thought generally involves intelligent purpose; and the mind thinks not only the present act but what that act will effect. Now the peculiarity of instinctive action, like that of the Beaver, is that it is not an unthinking hereditary habit connected only with sensation, but that each successive act is performed with thought; while, at the same time, thought is confined to the present act, or at most includes very little beyond it. The native impulse or desire seeks each step in succession irrespective of the result of the whole, because thought cannot take in the end of the series.

But this limited scope of thought which is unable to take in a series of acts, is far from being characteristic of the intelligence of Vertebrate animals in general. On the contrary, those which have a more developed brain plainly exhibit in their actions intelligent purpose, a power of thinking the means in connection with the end, so as to have present to their consciousness a sense of a series of acts leading to a desired result. Of this many examples might be given, but it may be sufficient to quote as an illustration of it the following anecdote of a dog, from Mr Watson's book, on the *Reasoning Power in Animals*, p. 130.

"Count Tilesius, a Russian traveller, who wrote at the beginning of the present century, relates a most remarkable proceeding of a dog of his, which he himself witnessed. The dog in one of his excursions from home had been worried by an animal of greater strength than himself, and returned crest-fallen. For some time afterwards it was observed that he abstained from eating half of the food given him, but carried away the other half and laid it up as a private store. When he had gone on thus for some days, he one day went out and gathered round him several dogs of the neighbourhood, whom he brought to his home and feasted on his hoard. This singular assemblage attracted the count's attention. He watched their movements, saw them all go out together, and followed them at a distance. They proceeded deliberately onwards through several streets till they came to the outskirts of the town, where, under the guidance of their leader, they all fell upon a large dog, whom they punished with great severity."

Now this series of actions is of such rare or merely occasional occurrence in the life of a dog, that it cannot be accounted for on the supposition that by that process of association which grows out of frequent repetition, the gratification of attaining the end had mingled with the thought of all the means, and rendered them in themselves attractive in succession. There may, indeed, be in the dog, as a gregarious animal, an inherited tendency to look for help in circumstances which make help needful, and possibly a tendency to court the alliance of other dogs by giving them food, though this is more probably due to his own intelligent sense of their feelings. But the further step of saving his food instead of eating it can hardly be an instinctive impulse awakened by the circumstances but without conscious purpose; for it requires so strong an impulse that the instinct should be one in full action, and therefore of frequent occurrence. The sense of injury would arouse the instinct of revenge. This from inherited or acquired association would be followed by a desire for help. This would suggest the giving of food, and this the storing of food. And each time that food was present the sight of it might awaken these thoughts in succession. But if it was only in succession that the dog could have these thoughts, losing the consciousness of each as he passed to the next, the original desire for vengeance which would mingle in some degree with the second thought, and perhaps might even tincture the third, would be so faint in the fourth, if it were present at all, that the strong instinct of eating the food would prevail over the mere idea of storing it. That there might be an active desire to store the food sufficiently strong to make the dog abstain from it, there must have been present to his consciousness along with the idea of storing it a thought of giving it to the other dogs, and gaining their help to gratify his revenge. He must have had a power of thinking a particular act as a part of a series, combining with the idea of that act a thought of the series of acts leading to their result.

Now wherein does this differ from the power which the human mind possesses of forming a plan to attain an end? If what has been stated contains the whole of the action of intelligence which was involved in the proceedings of the dog, then those proceedings reveal only a power of thinking, as a whole, a series of acts, each with its effect, and all with their result. But the human mind adds to this the further power of believing, with more or less certainty, that each step in the series of acts which it plans will be followed by the consequence connected with it in thought. Now this implies inference from past experience; and after all that has been written on the process of inference or reasoning properly so called, we must, if we are to distinguish it from mere association of facts, come back to the old theory, that inference is the process of imparting to the idea of a fact the degree of assurance which belongs to it, as a case of a general principle.

Mr Darwin, in his *Descent of Man,* p. 41, mentions a female baboon who adopted young dogs and cats, which she continually carried about; and he tells that an adopted kitten scratched this affectionate baboon, "who," he says, "certainly had a fine intellect, for she was much astonished at being scratched, and immediately examined the kitten's feet, and without more ado bit off the claws." Now such an act of intelligence seems to be beyond the powers of a dog. In the *Wonders of Animal Instinct,* from the French of Ernest Menault, p. 363, the following acute distinction is drawn between the intelligence of the ourang-outang and that of the dog.

"The ourang-outang, without being instructed by man, does accomplish acts of which the most sagacious and best instructed of our dogs is incapable. If the dog is chained up, and the chain becomes entangled, the animal pulls it forcibly towards him, and often increases the evil, instead of removing it. If the obstacle continues, be becomes frightened and cries out, but never thinks of searching into the cause of the mischance. It is not so with the ourang-outang. The moment a similar accident happens to him, he tries to find out the real state of things. You will not see him pulling against a powerful obstacle with blind force. He stops at once, as a man would do in similar circumstances. He turns round to examine the cause of the occurrence. If the chain be entangled by a heap or weight of any kind, he disengages it. In every case he seeks the why and the wherefore. Is not this seeking for causes a manifest sign of intelligence?"

Now it is much more than a sign of intelligence, it is evidence of the power of thinking a fact with belief as a case of a general principle; and that power is the power of reasoning. The dog whose chain is entangled finds himself unable to perform the action which has become usual to him under the circumstances; and he is merely disturbed by this impediment to the regular play of his associations. The ourang-outang sees in this check to his usual action something more than the fact that he is checked, namely, the presence of a thing not yet known, altering the usual action of the chain. If, indeed, such a thing had been observed before acting in this way sufficiently often to form an association, the dog would think of it as well as the ourang-outang. And if its removal on those occasions had relieved him, the dog too would think of removing it. The supposed case, therefore, is one in which such an association has not been formed. The ourang-outang may never before have been confined by a tangled chain; the baboon may never before have been scratched by a paw. The thought which each occurrence suggests to them is a fine abstraction from a far wider experience, namely, the presence of a new condition to a new action. This is a fine element of fact which belongs in common to a number of facts. It might be connected in thought with the present fact by mere association of those other facts in which it was an element. But when thus thought, it would be too faint to attract the attention of the mind and govern action. In order that such an abstract element of past experience should govern action, it is necessary that it should be strengthened with a new element of belief and combined in a sense of reality with the present object. It will thus become strongly noted as part of that object, and will engage the desire which that object inspires. To the ourang-outang in the one case, and to the baboon in the other, the thought of a new circumstance as condition of a new action was no abstract conception, but a special part of the idea of the present fact; and it attracted action, suggesting the way in which the unpleasantness was to be removed. It was thought with a power which the dog does not possess, the power of combining in an assured sense of reality with the idea of an object some abstract coexistence or succession which has been gathered from similar objects as a uniformity of experience; the power, in a word, of thinking a case of a general principle with the belief which belongs to it as such.

Now this step of mental development which may be observed in the ourang-outang, as compared with the dog, is similar in its essential nature to the previous step to which it is superadded, and which may be observed in the dog compared with the lower vertebrate animals. The dog can combine with the idea of an act, a thought of a further series of acts leading to a result, so as to think the act with purpose as part of the series. The ourang-outang can combine with the idea of a fact or thing, a thought of other similar facts or things, singling out an element in which they more or less uniformly agree, so as to think the fact or thing with more or less assurance as another instance of the uniformity. Each is a new power of combining thoughts which otherwise would have required a long course of repetition in conjunction with each other, before they could have grown together. And each combines those thoughts in a closer and more vivid union through the medium of a new element, namely, sense of progress towards an end in the one case, and belief in the maintenance of a uniformity in the other.

But can the progress of mental development be traced through the Vertebrate series of animals as having advanced by these steps? Can they be classed in reference to their mental powers in three groups, of which the lowest can comprise in one act of thought only what can be perceived by sense all at the same time, the second can comprise in one act of thought a series of successions in time so as to think a single object of sense as part of such a series, and the third can comprise in one act of thought an entire class of coexistences or successions so as to combine with a particular fact the common element of coexistence or succession belonging to the class?

The operations of birds in the building of their nests are evidently of the same character as those of the beaver in the construction of his dam. They plainly proceed from an instinctive impulse which is independent of conscious purpose, and which acts even where the circumstances are inconsistent with the end to which it leads. They indicate therefore no larger power of mind than that which is limited in each of its acts to the thought of one object of sense, and which cannot think a successive series with its result; and the same may be said of the migratory instincts of birds. But it is rather in occasional manifestations of intelligence that the highest mental power possessed by any class of animals is to be seen; for in every class the actions which are habitual come to be performed by the lower powers. Now the intelligence of birds never reaches to the comprehension of a number of different successive acts, nor to the thought of a principle.

The case of the jackdaws, quoted from Mr Jesse by Dr Carpenter, seems indeed to indicate a power of thinking in one thought a series of acts leading to a result, but closer examination shews that this is only apparent.

"A pair of jackdaws endeavoured to construct their nest in one of the small windows that lighted the spiral staircase of an old church-tower. As is usual, however, in such windows, the sill sloped inwards with a considerable inclination; and consequently there being no level base for the nest, as soon as a few sticks had been laid, and it was beginning to acquire weight, it slid down. This seems to have happened two or three times; nevertheless, the birds clung with great pertinacity to the site they had selected, and at last devised a most ingenious method of overcoming the difficulty. Collecting a great number of sticks, they built up a sort of cone upon the staircase, the summit of which rose to the level of the window-sill, and afforded the requisite support to the nest. This cone was not less than six feet high, and so large at its base as quite to obstruct the passage up the staircase; yet, notwithstanding the large amount of material which it contained, it was known to have been constructed within four or five days. Now, as this was a device quite foreign to the natural habit of the bird, and only hit upon after the repeated failure of its ordinary method of nest-building, the curious adaptation of means to end which it displayed can scarcely be regarded in any other light than as proceeding from a *design* in the minds of the individuals who executed it."

The question is, does this indicate that jackdaws possess the power of comprising in one act of thought a series which sense could perceive only in succession?

Now the cone of sticks is a single object of sense. The idea of it may have been formed by successive acts of thought, suggested first by the need for a support at the base of the nest, and then by the need for an additional support for this, and so on, till a bottom was reached; but each such thought would combine with the preceding ones into an idea of a single object of sense. The last element added to the idea would be the thought of the foundation; and this would suggest the first act of construction; and the process of construction would proceed, realising in succession the ideas of the successive parts without ever involving the thought of more than a single object of sense. The device was foreign to the natural habit of the bird, yet not quite foreign to the thoughts which the nest-building instinct involves. For the various peculiarities of the sites chosen for nests must awaken in birds instinctive associations of corresponding varieties of construction, and these must involve ideas of supports, and of the other requisites for stability.

The nest-building instinct must also often involve a desire for shelter and protection; and with those birds which have vivid and distinct mental action, a special need for shelter may awaken instinctive associations which suggest the construction of artificial shelter. Such constructions may seem to require a number of different ideas thought together in a plan, but they do not really imply the thought of more than a single object of sense at one time. Thus a pair of magpies in a neighbourhood where there were no trees, built their nest in a gooseberry-bush, and frequented it for years. But as it was accessible to foxes, cats and other animals, they barricaded with a circle of briars and thorns not only the nest, but the whole bush[1]. In this case the desire for protection would operate successively with regard to each side of the nest, and would suggest successively the erection of each piece of the barricade, without ever thinking more than a single object at once.

For it is to be noted that when an object is thought with desire, and when it suggests through former association what led to its own attainment, the desire will attach itself to this suggested idea, even though there be no power of thinking means and end together. In order that the original desire should thus be taken up by a series of means, so as to cause them to be sought after one another as ends, a process of association is necessary which requires a long course of repetition; but this would never take place, unless there was a partial transfusion of desire to the nearest means in the first instance. And when the desire is strong this transfusion will be sufficient to cause the immediate mean to be sought even where each thought is limited to one object of sense. Thus birds as well as mammalia seem to have intelligence enough, when accustomed to the company of man, to associate human intervention with relief of their distress in special cases, and to apply to man for help; and when his help has come to them in a painful form, as for example in a surgical operation, they continue to desire it notwithstanding the present pain. But there is no evidence that any animal below the order to which the beaver belongs can think a series of sense perceptions, or a general principle; though there may be cases which simulate these powers. The old story of the raven throwing pebbles into water as if to raise its level, seems to indicate the knowledge of a general principle, but if the incident ever occurred, it was more probably a suggestion from the familiar act of standing on a stone to drink in a stream; in which the bird thought only this single act.

[1] Watson's *Reasoning Power in Animals*, p. 318.

In the order of Rodents to which the beaver and the rat belong, we first meet the power of thinking a series of acts, but this power is still so limited in them that the series of acts which they perform with conscious purpose, consist only of one or two acts, or of one or two acts repeated over and over again. A more diversified series of acts, like that which is required in the construction of the beaver's dam, is with them instinctive. Moreover they seem to have a tendency to perform those actions which involve the most design in combinations in which several are engaged, each one doing a part of the action. This is a feature of resemblance to the intelligence of insects, and corresponds to a limited power of thinking a series of acts. For this simultaneous performance by the community, of all the steps leading to an end, helps to enable each to perceive by sense the entire series all at the same time. The Ruminants have a larger power of thinking a series of acts, as may be seen in the artifices of the hunted stag, though it is hard to say how much of these may be instinctive; and still more clearly in the intelligence of the oxen of the Hottentots, which in war fight with the Hottentots against their enemies, and in peace perform for them the same services that are elsewhere performed by dogs. In the Pachydermata, the power of plan and purpose, and of understanding a series of acts which is expected from them, is clearly manifested by the elephant. And though the other pachydermata are so inferior in intelligence to the elephant, the inferiority is not in the nature of their thoughts, but in vividness and distinctness. In the Carnivora, the intelligence of the dog and of the fox, and of the other animals of the order, exhibits clearly the power of design; and the Dog moreover shews his power of thinking a series of acts by the signs which he gives of feeling guilty or ashamed or proud on account of his conduct. In the Quadrumana there appears for the first time, in addition to the powers of purpose, a sense of general principles; and this, as has been shewn, appears with clearness in the anthropoid apes.

Now such being in outline the development of the powers of intelligence in vertebrate animals, what is the course of development of their brain?

This question may be answered by the following quotation from Dr Carpenter's *Mental Physiology,* p. 116.

"That the different portions of the Cerebrum should have different parts to perform in that wonderful series of operations by which the Brain as a whole becomes the instrument of the mind can scarcely be regarded as in itself improbable. But no determination of this kind can have the least scientific value that is not based on the facts of comparative Anatomy and Embryonic Development. In ascending the Vertebrate series we find that this organ not only increases in relative size and becomes more complex in general structure, but undergoes progressive additions, which can be defined with considerable precision. For the Cerebrum of Oviparous Vertebrata is not a miniature representative of the entire Cerebrum of man, but corresponds only with its 'anterior lobe,' and is entirely deficient in that great transverse commissure, the corpus callosum, the first appearance of which in the Placental Mammals constitutes 'the greatest and most sudden modification exhibited by the brain in the whole Vertebrated series.' (Huxley.) It is among the smooth-brained Rodentia that we meet with the first distinct indication of a 'middle lobe' marked off from the anterior by the fissure of Sylvius; this lobe attains a considerably greater development in the Carnivora; but even in the Lemurs it still forms the hindermost portion of the Cerebrum. The 'posterior lobe' makes its first appearance in Monkeys, and is distinctly present in the Anthropoid Apes. The evolution of the Human Cerebrum follows the same course. For in the first phase of its development, which presents itself during the second and third months, there is no indication of any but the anterior lobes; in the second, which lasts from the latter part of the third month to the beginning of the fifth, the middle lobes make their appearance, and it is not until the latter part of the fifth month that the third period commences, characterized by the development of the posterior lobes, which sprout as it were from the back of the middle lobes, and remain for some time distinctly marked off from them by a furrow."

These facts of embryonic development give great significance to the facts previously mentioned of Comparative Anatomy. And the latter have such correspondence with the sketch just given here of the development of the powers of intelligence, as at once to suggest that the functions of the anterior lobe belong to the act of thinking single objects of sense, those of the middle lobe to the act of thinking such objects with a sense of a succession of them and as part of that succession, and those of the posterior lobe to the act of thinking a coexistence or succession of them as a case of a general principle. But as the development of intelligence in vertebrate animals, even if the view just taken of it be correct, may be thought to be connected rather with other features of the development of the brain, and as the view taken of the course of development of intelligence may itself be questioned, it may be well to study the question from another point of view. I shall therefore consider briefly the functional meaning of those other features of brain-development as it may be suggested by the analogies of the nervous system itself, and that of the successive addition of the three lobes as it may be inferred from the analogies of development in general.

There are two other striking features in the development of the brain in the vertebrate series of animals, namely the progressive increase of the superficial or cortical layer of the brain, and the increased development of the fibres which connect together the different parts of the brain.

Now the superficial layer of the brain is the part where the nerve-force of the brain is developed, and its increase, supposing the functional activity of any given extent of it to remain undiminished, must be accompanied by an increased development of cerebral force, and therefore of mental action. Moreover, such an increase of the superficial layer, without any change of the relations of its parts, would magnify each part so that an amount of cerebral force corresponding to a thought might be developed in a smaller fraction of the whole. Thus the actions of the brain in connection with the mind would be subdivided and thought analysed; and the effect of the increased size of the cortical layer of the brain, in consequence of the increased number and depth of its convolutions, would be not only an increased amount of mental action, but also an increased subdivision of thought; that which was a single idea of an object being broken up at pleasure into a number of different ideas.

An increase of mental action corresponding to an increase of the convolutions may perhaps be seen in the indications observable in dogs that they dream in their sleep. It is more distinctly manifested in the curiosity displayed by monkeys, and in that general interest taken by them in objects irrespective of utility, which has caused some authors to impute to them an inferiority to other animals in common sense. But the increase of mental action is chiefly to be seen in whatever shews a habit of reflection. And though the higher animals may be observed contemplating objects, the power of reflection is scarcely open to our observation except in ourselves. In us it is developed in a degree corresponding to the enormous increase of the cortical layer of the brain and of its functional activity as shewn by the increased supply of blood.

The analysis of thought which is probably also connected with this particular brain-development breaks up the idea of a single object of sense into ideas of parts which are seen to constitute it. It is no doubt concerned in that observation of the way in which things act on other things which leads monkeys and apes to use instruments, though this is of course facilitated by their having hands. With this analysis of thought is connected the development of the powers of abstraction and comparison and perception of relation. For though these powers are possessed in their essence by all animals which can at will observe either separately or together objects which are together before their senses, yet in order that they may act with any degree of fineness a fine analysis of thought is needed. In human language, the analysis of thought reaches its acmé.

The second principal feature in the development of the brain is that of the system of nerve-fibres which connect the parts of the brain with each other. These must serve to make the action of the different parts of the brain consentaneous, and in doing so give correspondence to the muscular action of the two sides of the body, and strength and steadiness to thought. Attention and volition require this unfaltering unity of action; for if any part concerned did not concur decisively, its indecision would affect the other parts. And in proportion as powers of thought are developed which are less closely connected with sense, there is still more need of these connections to preserve that unity of action which the impressions of special sense, by reason of their decisive unity, give to cerebral action immediately connected with them. Accordingly the great transverse commissure which connects the two lateral halves of the cerebrum appears first with any degree of development worthy of notice in the Rodent order of the mammalia along with the middle lobe. Thus neither the convolutions nor the fibres of the brain seem to have any tendency to give that extension to thought which has been assigned to the three lobes. They improve the action of the brain rather than enlarge the range of its objects. But the development of each additional organ of intelligence extends the range of the objects of thought. And it is as superadded developments that the three lobes appear both in the vertebrate series of animals, and in the development of the human embryo.

And now what suggestions as to the functions of the three lobes may be derived from the general analogies of development as giving successively the advantages which are needed in the struggle for life[1]?

The general function of the cerebrum is to direct the actions of the body by thoughts of the mind to the attainment of desirable ends, and each distinct addition which it receives may be expected to correspond to a distinct enlargement of that power[2].

[1] The development spoken of is only that which is to be observed as a matter of fact in comparing the higher animals with the lower. Whatever theory be adopted as to the mode in which that development has been produced, it is a fact that in general each new development gives an advantage in the struggle for life, and that the general course of development corresponds with the satisfaction of these successive needs.

[2] It is an essential property of the nervous system to form associations, and any higher development of that system must exalt the power of association. When an action has been performed by a part of the nervous system, the restoration by nutrition of the force expended in the action seems to adjust itself to the then condition of the organ, so that when the action is performed again the organ in recovering its equilibrium after the action tends to be thrown into that same condition. And if on the first occasion the action was followed immediately by another action which quickened the life of the organ, as when an action gives pleasure, then the renewal of the first action will tend to throw the organ into a condition which is at the same time one of exalted life and one which it is natural for the organ to assume after the performance of the two actions in succession. The organ will then not only be quickened by the first action, but in the effort to attain equilibrium will tend to perform the second. And thus the sequence of two acts, of which the second gives pleasure, produces a twofold effect. It combines a degree of pleasure with the first act in its next performance, and it associates the second with it in a similar degree. Moreover, when the immediate effect of any action is to promote the life of the nervous system, as when an action gives pleasure, it seems by a general law of life to attract the force of the system while it is being performed, and to stimulate its nutrition afterwards. The disturbance caused by it in the first instance will be the greater, and when afterwards induced by an antecedent associated action will have the more force in eliciting it again to attain equilibrium; and the subsequent nutrition being accomplished more quickly while the one condition of the organ lasts, will correspond more closely to that condition, and cause it to be reproduced afterwards more faithfully. Thus an attractive action will have a special tendency to be associated with another

The intelligence requisite for the attainment of desirable ends consists of knowledge of the ends and knowledge of the means; but this degree of intelligence is only gradually attained. We find that in some animals which have no cerebrum certain sensations have become associated with the origination of certain muscular movements, so as to direct the actions of the body in accordance with the notices of external things which sensation gives. We must suppose that in these animals when a new sensation of a pleasurable kind has been imparted by an object, the presence of a similar object again will tend to recall that sensation. A mental state thus elicited by association follows that which calls it forth; and the obscure sensation thus recalled by the recurrence of the object will follow the impression which the object makes directly on the senses. Now the pleasure of the recalled sensation must be combined with the direct impressions made by the object, instead of only following them, in order that the present object, and not the mere past sensation, may be the object of desire. A pleasurable sensation thus awakened by association tends gradually to coalesce with that which often calls it forth. But this process is too slow for the prompt recognition of desirable objects; and the demand for development therefore will be the want of an organ to combine the successive impressions made by objects on sense, so as more rapidly to select by experience those objects which are desirable as ends for action. Accordingly the first function of the cerebrum should be to enable the mind to combine the impressions of sense into perceptions of sensible things, adding each new impression to the idea of the thing, as a quality inhering in it. Connected with this perception of desirable objects a power of thinking those objects in their absence is needed in order that they may effectively guide action by continuing to be the ends towards which it is directed. This need would be supplied by an action of the cerebrum on the sensorium, whereby the cerebral states which are produced by the impressions of sense may afterwards renew those impressions in the centres of sense, so as to supply ideas of absent objects; and accordingly the function

action which preceded it, and will also tend to infuse into that other action a portion of its own attractiveness. A painful action arouses the life of the nervous system to resist it, so that it too has a special tendency to form an association; but here the association is negative of the action.

of the first lobe of the cerebrum in connection with thought should be to act with the sensorium in the perception of sensible things, and afterwards in the renewal of the idea of them.

If we analyse our own consciousness we find that there is in every perception or idea of external things an element of thought which is the centre or nucleus of our idea of the thing. This element of thought, though it has no mental image, can be distinguished by the human mind as substance; and the thought of substance therefore in a more or less indistinct and rudimentary form is probably what corresponds to the first contribution which the cerebrum gives to the powers of thought. In this element the sensations are combined into unities; for to substance they are all referred as qualities inhering in it, and constituting with it sensible things. And the first rudiments of position and dimension are probably added to the ideas of things from the series of muscular sensations associated with the sight of them during the motion to them or about them. As the cerebrum grows in the vertebrate series of animals and thought gets subdivided, the comparative attributes of things and the relations of things are thought; new emotions, desires and aversions grow out of the associations of ideas of things with the pleasures and pains which are essentially involved in various modes of nervous action; and possibly that reaction of the cerebrum, whereby after one thought has been conceived another is elicited in the mind, may become localized in different parts and specialized as different powers for ordering the successions of thought, so as to compare, combine, observe relations, and awaken emotions; the cerebrum and sensorium being both probably in action whenever an idea or mental image is before the mind. The cerebrum is also connected with the centres of motion, combining into unities groups of muscular actions as it combines into unities groups of impressions of sense, and extending and facilitating the associations between thought and action. Simultaneously with the cerebrum the cerebellum also makes its appearance in vertebrate animals. It is believed to coordinate the actions of the muscles with one another; and as its connections are principally with the spinal chord, it probably serves as a store of force, which having been set in action by the contracted muscles through the posterior nerves, continues to maintain through the anterior nerves the stimulus to muscular action. Thus the cerebellum probably keeps up the activity of the groups of muscles which have been set in motion, that the momentary impulses which come from the brain may carry on with steadiness the progress of the action. For volition acts at each moment in producing slight changes in the existing action of the muscles, or directing that that action shall be unchanged or suspended.

Now after the power of thinking the ends of action the next development which is needed in the furthering of attainment is the power of thinking the means. For though the various steps in the process of attaining an end may be joined one to the other by association, action will not be moved to take those steps till the desire inspired by the end has been transferred to them, and this transference by association is, as has been said before, a gradual process. The same necessity therefore for a new power of combination which demanded the first development of the cerebrum in order to combine sensations into a perception of a sensible thing, will demand a fresh development of that power in order that the mind may think means in combination with their end, as leading to it. The desire inspired by the end will then combine with the means so as to prompt their adoption; and the idea of the means as such, that is as leading to the end, will be formed, and may be renewed in their absence so as to maintain the guidance of action.

Thus the middle lobe would be developed to act along with the anterior lobe so as to give a sense of the series leading to the end; though there can be no idea or mental image except of that part of the series with which the cerebrum is impressing the sensorium. To the middle lobe thus acting with the anterior would belong on this supposition the power of thinking acts with a view to their end, the power of thinking a series of occurrences, the distinct sense of time, a fuller development of that idea of space which springs from the sense of a series of muscular movements, the thought of action or fact as part of a series, and therefore involving time; and as substance is the special thought corresponding to the action of the anterior lobe, so fact or occurrence in time would be the special thought corresponding to that of the middle lobe, combining into a unity the series comprehended within the time of occurrence, and inhering in a subject which is thought by means of the anterior lobe and sensorium. As the cerebrum grew in the development of the vertebrate series and thought was subdivided, the relations and the comparative attributes of facts and actions would be thought, and new emotions, desires and aversions would be formed in connection with them. Particular powers of combining them and comparing them, and thinking them with an emotional sense of them, might possibly be located in different parts of that region of the cerebrum which consists of the anterior and the middle lobe, and it would be the seat of all moral judgments on action which are formed by association with facts. To that region would belong whatever is expressed in language by the verb, including its infinitive, gerund and participles; and it is some confirmation of this view, that, among the strange effects of cerebral disease producing Aphasia or loss of correct speech, it is found that sometimes the nouns are lost while the use of verbs is unimpaired, and sometimes the contrary; as if the verb belonged to a different part of the brain from the noun. With muscular action the middle lobe would have indirect connection through the anterior, and in consequence of its immediate union with the anterior it might conceivably acquire direct connections of its own.

Now if such be indeed the course of development, each lobe carries forward by one step the power of directing action to the attainment of its object. Through the anterior lobe the mind combines with the ideas of things the sense of desirable impressions as qualities inhering in them, so as to think things as desirable ends of action; and through the middle lobe it combines with the end of action steps in the process of attainment so as to think these as means leading to it. But another power is needed for the secure guidance of action towards attainment. A desirable quality may be erroneously attributed to an object which does not possess it. Means may be thought as leading to an end which they have no real tendency to secure. In order that action may be directed rightly a further development of intelligence is needed. Not only must there be the *thought* of ends and of means, but the *knowledge* of ends and of means—the power of judging by past experience whether the object really has the quality, and whether the means are really conducive to the end. There may arise from association with the past experience of similar cases a suggestion of the quality, as belonging to the present object, or of the means as conducive to the present end; and this suggestion will be more or less strong according to the frequency and uniformity and interest of the past experience. But the strength or weakness of the suggestion is not sufficient guide to the reality or unreality of that which is suggested. The idea of it may be weak because the experience of it was scanty though quite uniform. And the idea of it may be strong because the experience of it was accompanied by special interest, though there were many cases in which it was not realised. What is needed is a sense of the degree of uniformity of occurrence in cases similar to the present, and the extension of that degree of uniformity to the present case; in other words, a power of thinking the degree of uniformity of past experience in combination with the present case, so as to impart to the present case a belief in the presence of the element proportioned to that uniformity. This should be the next development; and accordingly the posterior lobe should act along with the middle and anterior lobes in such a way, that when by the associations which they form the thought of a fact or thing awakens the thoughts of other like facts or things, then the posterior lobe shall receive the impressions of those other ideas, so as to strengthen the sense of an additional element in which they agree, and strengthening that element in proportion to the uniformity of the agreement, to combine it in a corresponding strength of apprehended fact with the object which is before the mind. This would be in a more or less rudimentary form, according to the degree of development, the power of thinking a fact as a case of a principle. It is the physiological expression of the first obscure beginning of syllogistic reasoning. To the posterior lobe thus acting with the middle and anterior lobes would belong, according to this view, reasoning and principle and all the tendency to generalise in the sphere of fact and in the sphere of morality. As the cerebrum grew in the course of vertebrate development and thought was subdivided the relations and comparative attributes of general principles would be thought, and possibly special powers of dealing with general principles and seeing emotional aspects of them might be localised in the cerebrum. The associations of action with reward and punishment, approval and disapproval, already formed by the instrumentality of the middle and anterior lobes, would be generalised by that of the developed cerebrum into universal principles of morality inherent in the nature of things, and the constraining influence which such associations exert on conduct would be elevated into natural obligation. And in the unity of all perfect law referred to its source and author the human mind would at length attain to its highest idea of God.

Thus the hypothesis with regard to the functions of the three lobes of the cerebrum which is suggested by the natural order of development as determined by the great requirements of life, is that which the closest analysis of the degrees of intelligence in vertebrate animals seems also to indicate. So that though each class of facts is so intricate and obscure, as scarcely to afford a solid footing for investigation, yet their agreement may perhaps be considered to give a degree of positive probability to the general views here given of the mechanism of thought in the brain. And if it be objected that considerable portions of the cerebrum may be removed without any apparent mutilation of the powers of thought, shewing that no part of the cerebrum is specially connected with any act of the mind, it is to be observed that the acts of the mind become by association so connected with each other, that in each thought there are many associated elements, and the corresponding seat of cerebral activity would be not in one but in many localities throughout the brain. Even if some of these were removed, the action of the others would still by association elicit and be elicited by the accustomed impressions of the sensorium and stimulation of the centres of muscular action.

CONTRIBUTIONS TO THE ANATOMY OF THE INDIAN ELEPHANT, PART IV. MUSCLES AND BLOOD-VESSELS OF THE FACE AND HEAD.

By M. WATSON, M.D., *Professor of Anatomy in The Owens College, Manchester*[1].

THE NOSE.

ON reflection of the levator proboscidis muscle the nasal cartilage is exposed to view. It consists of a large flattened piece of cartilage six inches in length, in shape resembling one valve of a bivalve shell, and attached by its inner margin to the septum narium, whilst its outer margin is prolonged by means of a stout fibrous membrane as far as the external margin of the anterior narial aperture. On tracing it up, the cartilage is seen to sink into the anterior nares, describing a spiral curve as it descends. This spiral curve has its concavity directed toward the septal cartilage, and terminates in a free projecting margin, which in the natural condition of the parts is directed inwards so much as to diminish the narial passage to a very considerable extent, whilst by its outer margin it is attached to the external bony wall of the nares. Connected to the outer convex surface of the nasal cartilage is a strong fibrous membrane, which, on being traced outwards, is seen to be attached to the anterior margin of the external osseous boundary of the anterior nares. This membrane, along with the external wall of the anterior narial aperture, form the boundaries of a large air-space which communicates inferiorly with the narial canal of one side, as also by means of an aperture of large size, visible in the dried skull with the air-sinuses of the diploe, which in their turn communicate freely with one another. It is by means of this communication that these sinuses are supplied with air from the nasal cavity.

From the arrangement just described, it will be observed that the lower and internal margin of the nasal cartilage pro-

[1] Parts I. II. III. are in the November numbers of this *Journal*, for 1871, 1872, 1873.

jects into the narial tube in such a manner as to form as it were a valve, which in the natural condition of the parts hangs free in that tube and separates it into two compartments. By means of the external of these a free communication is maintained between the bony nostril and the air-sinus already described, whilst the internal permits of the continuity of the air-tube prolonged forwards to the trunk with the cavity of the nose. Under the action of certain muscles, to be presently described, however, this valve-like cartilage can be drawn outwards, so as to occlude the opening of the air-sinus, and thus shut off the communication of this with the cavity of the nose. This, I believe, is an arrangement calculated to obstruct the flow of water into the air-sinuses of the skull during its passage along the narial tubes. The muscles which act upon the nasal cartilage just described are three in number. Of these, two are arranged so as to act upon the spiral portion of the cartilage, whilst the third elevates that portion of it which overlaps the nasal tube. Of the former, one arises from the outer side of the nasal bone, and, passing downwards, is inserted into the anterior free margin of the spiral cartilage; whilst the other, arising from the outer concave margin of the arterior nares, and passing downward and inward, is inserted into the upper surface of the spiral cartilage as well as into its free margin. Both of these muscles will tend to pull outwards the lower part of this cartilage, and so close the external of the two passages into which it divides the nostril. The third muscle arises from the anterior margin of the nasal septum, and, passing outwards, is inserted into the upper convex surface of that portion of the nasal cartilage which lies over the nasal tube, which it evidently raises when in action.

The nasal tube of each side is a stout fibrous tube which continues forward the bony nostril to the extremity of the proboscis. It is attached superiorly to the upper aperture of the bony nares as well as to the spiral nasal cartilage. It passes downwards, resting at first on the corresponding intermaxillary bone, and is then continued on to the extremity of the trunk. In its course along the trunk it gradually narrows in calibre from the root to the tip, but its narrowest part is that which rests upon and corresponds in length to the intermaxillary bone; above this—that is, in the superior narial aperture—the tube dilates considerably, and lies under cover of the projecting piece of the nasal cartilage. Lying in relation to the roof of this portion of the tube is a large mass of mucous glands, which are concealed by the cartilage. The numerous openings of the ducts of these little glands are visible on the interior of this portion of the nasal tube, which at this spot is perforated by them. These would appear to be the sole source of the supply of mucus to the nasal tube, as nowhere else throughout its course are any such glands to be detected. A number of muscular fibres arise from the anterior margin of the outer wall of the bony nostril, and are inserted into the lower surface of this dilated portion of the nasal tube.

Arteries of the Head and Neck.

THE COMMON CAROTID

arteries of both sides arise from the trunk of the innominate, and pass forward on either side of the trachea and larynx, as far as the angle of the jaw, where each divides into the external and internal carotids. Each is accompanied in this course by the internal jugular vein and pneumo-gastric nerve, which lie to their outer sides.

Branches.—Two branches are given off from the common carotid artery.

1. *Superior thyroid*, which passes to supply the anterior portion of the thyroid gland.

2. A short trunk, which, arising from the inferior aspect of the main artery, divides at once into several branches for the supply of the œsophagus and trachea. One of these, of larger size than the others (*the laryngeal artery*), pierces the thyro-hyoid membrane, and is distributed to the larynx.

EXTERNAL CAROTID ARTERY

is given off from the trunk of the common carotid to the inner side of the ramus of the lower jaw, and passes outwards and upwards to gain the posterior aspect of the articulation of that bone, where it divides into the temporal and internal maxillary arteries. In this course it gives off the following branches:—

1. THE LINGUAL ARTERY,

which is a branch of considerable size, and arises close to the following. It runs almost horizontally forwards under cover of the hyo-glossus muscle, to gain the lateral margin of the root of the tongue, where it divides into its terminal twigs. One of these continues along the outer border of the genio-glossus muscle, toward the tip, whilst the other ascends to supply the dorsal aspect of the root of the tongue.

Branches.—As the artery lies under cover of the hyo-glossus, it gives off two branches of considerable size, which ascend to supply the soft palate.

2. FACIAL ARTERY

comes off immediately in front of the lingual, and passes obliquely downward and forward to gain the angle of the jaw, round which it turns, and appears upon the face, where it divides into two branches. One of these runs forward parallel to the upper border of the lower jaw, and, anastomosing with the mental artery, is continued upwards in the substance of the lip, of which it forms the coronary artery. The other branch passes backward, and supplies the buccinator muscle.

Before the artery reaches the face it gives off the *sublingual branch,* which, running forward on the surface of the mylo-hyoid muscle, terminates by supplying that muscle.

3. INTERNAL MAXILLARY ARTERY,

the largest of the three anterior branches of the external carotid, passes obliquely forward and upward, resting against the inner side of the temporo-maxillary articulation, and crosses over the styloid process of the temporal bone. Having reached the base of the skull, it passes through the spheno-palatine canal, beneath the orbit, and appears at the root of the proboscis, after traversing the infra-orbital canal. The artery (infra-orbital) then sinks into the interval, between the superior and lateral muscles of the trunk, and is continued along the lateral margin of that organ, under cover of its longitudinal muscles, as far as the extremity. As it lies in relation to the trunk, it is contained within a fibrous canal, and is accompanied for some distance by a large branch of the superior maxillary nerve.

It gives off numerous branches for the supply of the proboscis, one of which, larger than the others, leaves the artery immediately above the incisor tooth, and proceeds along the dorsal aspect of the proboscis, which, with the others, it supplies.

The branches given off by the internal maxillary are as follows:—

1. *Meningeal artery*, which is given off before the parent trunk passes into the spheno-palatine canal. It passes upwards and backwards, and, having pierced the base of the skull, is distributed to the meninges. It is from this artery that the mucous lining of the air-sinuses of the skull receives its supply of blood.

2. *Posterior deep temporal artery*, given off immediately in front of the preceding branch, runs upwards and supplies the posterior portion of the temporal muscle.

3. *Anterior deep temporal artery* passes off from the internal maxillary after it has passed through the spheno-palatine canal, and ascending, is distributed to the anterior portion of the temporal muscle.

4. *Pterygoid artery* of small size runs downwards and supplies the muscles of the same name.

5. *Buccal artery* of large size describes a curve downward and forward, and is distributed to the buccinator muscle.

6. *Ophthalmic artery* of considerable size is given off as the internal maxillary is about to enter the infra-orbital canal. It runs forwards and upward, and entering the orbit supplies the structures situated in that cavity. Several of its branches emerge on the face after passing through the orbit.

7. *Superior dental artery* leaves the internal maxillary as it lies in the infra-orbital canal. It passes through the canal of the same name, and is distributed to the teeth of the upper jaw.

4. TEMPORAL ARTERY

is the direct continuation of the external carotid. It passes up behind the articulation of the lower jaw and under cover of the parotid gland as far as the zygoma, where it divides into two terminal branches. The posterior, the smaller, passes up to the vertex of the cranium, whilst the anterior, considerably larger, runs upward and forward in the direction of the orbit. These branches are the main sources of supply to the temporal gland.

Branches. 1. *Posterior auricular* is of large size, and passes upward and backward behind the ear, the auricle of which it supplies; as it lies in relation to the parotid gland, it gives off numerous branches of supply to that gland, as also the *stylo-mastoid* artery, which, ascending vertically, passes into the stylo-mastoid foramen in company with the facial nerve.

2. *Inferior dental artery* passes off from the front of the temporal, and running downwards enters the dental canal to appear subsequently on the face as the *mental artery.* It gives off a small *mylo-hyoid* branch.

3. *Sub-zygomatic artery,* a short trunk, which divides directly into the *masseteric artery,* which enters the posterior border of that muscle and the *transverse facial artery,* which runs along the lower border of the zygoma, and is distributed to the parts lying superficial to the masseter muscle.

INTERNAL CAROTID ARTERY

runs forward to reach the base of the skull through the carotid canal of which it passes, and divides within the cranial cavity into two branches. One of these, the *anterior cerebral artery,* passes forwards and dips into the longitudinal fissure of the cerebrum. It is connected to the corresponding branch of the opposite side by the *anterior communicating artery.* The other branch passes backward, and anastomoses directly with the vertebral artery.

VERTEBRAL ARTERY

is a branch of the subclavian. It enters the foramen of the transverse process of one of the cervical vertebræ behind the fifth, and passing through the series of foramina, turns inwards, lying in a deep groove on the arch of the atlas, which it perforates. Appearing on the base of the skull it anastomoses with the posterior branch of the internal carotid artery of the same side. The circle of Willis is therefore incomplete posteriorly. It gives off numerous branches in the cervical region, one of which of large size passes upwards and supplies the muscles behind the head, and consequently takes the place of the occipital artery, which is absent. From the cranial portion of the artery a number of branches are given off to supply the posterior lobes of the cerebrum as well as of the cerebellum.

Veins of the Head and Neck.

INTERNAL JUGULAR VEIN

receives the blood from the sinuses of the dura mater, and is attached to the margin of the jugular foramen. It passes backward, lying to the outer side of the internal and common carotid arteries to the root of the neck. In this course it receives blood from

1. SINUSES OF THE DURA MATER.

1. The *great longitudinal sinus* and the *small longitudinal sinus* contained within the substance of the falx cerebri, which both terminate in the torcular Herophili. The former receives the blood from several smaller sinuses, which run transversely, and form a right angle with the main channel at their entrance into it.

2. The *occipital sinus*, which, passing upwards, terminates in the torcular Herophili.

3. Another sinus of large size is formed by the junction of one from each side in the middle fossa of the base of the skull, and passing horizontally backward, becomes continuous through the foramen magnum with a large sinus of the spinal dura mater. The two tributaries of this sinus come one from either side of the pituitary fossa.

4. A sinus of large size passes from the upper part of the cerebellar fossa of each side, and, bending forwards, opens into the lateral sinus of its own side.

5. The *lateral sinus* passes down along the line of attachment of the tentorium, and opens finally into the jugular vein at the foramen of that name.

The sinuses situated on the roof of the skull received numerous veins from the cerebral hemispheres, which opened into them by means of peculiar valvular openings, visible on the inner surface of the dura mater.

2. TEMPORAL VEIN

arises from the temporal rete—already described in connexion with the temporal fossa—by the junction of three or four main trunks, which, passing downward superficial to the companion artery, finally open into the internal jugular behind the angle of the jaw. The temporal vein receives—

The *masseteric veins,* two in number, and of large size, which, after uniting into a single trunk, and receiving the *transverse facial vein,* terminates in the temporal.

3. INTERNAL MAXILLARY VEINS.

These are two in number, on each side, and are the direct continuation backwards of the companion veins of the infra-orbital artery. They do not accompany the artery through the spheno-palatine canal, but are separated from it by the internal pterygoid muscle. Finally, they unite into a single trunk, which enters the internal jugular just below the articulation of the lower jaw. It receives—

1. *Ophthalmic vein* from the orbit.
2. *Lingual veins,* two in number, which accompany the artery, and finally form a single trunk, which opens into the maxillary vein just before the latter joins the jugular.

4. FACIAL VEIN

arises from a venous plexus situated immediately in front of the orbit, by means of which it communicates with the internal maxillary veins. It passes obliquely downward and backward, and crosses the lower jaw in front of the masseter muscle. Here it is separated from its companion artery by the digastric muscle, and opens into the internal jugular vein immediately below the point of entrance of the internal maxillary vein.

5. POSTERIOR AURICULAR VEIN,

which accompanies the artery of the same name, but is separated from it below by the digastric muscle.

VERTEBRAL VEINS

are two in number, and of large size. They accompany the artery.

Muscles.

1. FACIAL MUSCLES.

1. *Panniculus carnosus* passes up from the side of the neck over the angle of the jaw to the face, where it expands and is inserted as follows:—The lower fibres are inserted into the outer side of the body of the lower jaw, the upper are inserted into the strong aponeurosis covering the cheek, whilst the intermediate are continued forward to the angle of the mouth, along with the fibres of the next muscle.

2. *Zygomatico-labialis* is quadrilateral in form, and arises from the facial aponeurosis between the zygoma and the lower jaw. The fibres pass forward and blend with those of the orbicularis at the angle of the mouth, which it evidently retracts.

3. *Orbicularis oris* passes continuously round the angle of the mouth from the chin, where it is continuous with the corresponding muscle of the opposite side to the root of the trunk, along the side of which it blends with the lateral muscles of that organ. The fibres forming the free margin of the lips are much finer and more closely packed than the external portion of the muscle, which is intermixed with a large quantity of fibrous tissue. Opposite the angle of the mouth the fibres of the preceding muscle blend with those of the orbicularis.

4. *Levator labii superioris* is triangular in form, and arises from the anterior portion of the supra-orbital ridge immediately in front of the orbicularis palpebrarum by a pointed attachment. The fibres diverge as they pass down to the upper lip, and are inserted in this way. The anterior and stronger portion of the muscle is inserted into the lip immediately above the root of the tusk, whilst the posterior and weaker bundles are inserted into the facial aponeurosis directly beneath the eye. At its origin it lies over certain of the lateral muscles of the trunk.

5. *Orbicularis palpebrarum* consists of two sets of fibres, an internal and an external. The internal finer fibres are attached to the projecting spine of the lachrymal bone in front of the eye, and pass continuously round the upper and lower eyelids. The external portion of the muscle is confined to the anterior and posterior regions of the eye, and does not,

like the inner fibres, surround it continuously. The *anterior* division arises along with the inner fibres from the spine of the lachrymal bone, and certain of these fibres pass upward, others downward. The former are inserted into the facial aponeurosis *above* the eye, whilst the latter are inserted in the same manner *below* the eye. The *posterior* division of the muscle arises from the post-orbital spine, and the fibres describing segments of circles pass to be inserted into the facial aponeurosis behind and below the eye. In front the muscle corresponds to the levator labii superioris, whilst posteriorly it comes into relation with the occipito-frontalis.

6. *Occipito-frontalis* is, as in the human subject, a double-bellied muscle with an intermediate tendon. The *posterior* belly, much the larger, arises from an aponeurosis covering the superior and lateral aspect of the cranium immediately above the posterior part of the temporal fossa. The fibres pass obliquely upward and forward, and terminate on a strong aponeurosis covering the temporal fossa, and attached above to the temporal ridge. The *anterior* belly of the muscle arises from the post-orbital process, and, passing backward, terminates on the aponeurosis before described. The muscle is subcutaneous, its anterior belly coming into relation with the posterior fibres of the orbicularis palpebrarum, whilst the posterior belly at its origin is in contact with certain of the muscles of the ear.

7. A *cutaneous muscle*, which may perhaps be regarded as a portion of the panniculus, arises from the cranial aponeurosis of the posterior surface of the skull. The muscle measures three inches in breadth, and the fibres passing transversely outward are inserted into the cranial aponeurosis immediately behind the origin of the posterior belly of the occipito-frontalis.

2. MUSCLES OF THE EXTERNAL EAR.

These, for the sake of convenience, may be divided into three groups—1st, Those whose origin is situated *behind* the external auditory meatus (retrahent muscles); 2nd, Those whose origin is situated *in front* of the external meatus (attrahent muscles); and, 3rd, Those whose origin is placed *above* the meatus (attollent muscles).

The first group comprises four muscles:—

1. *Retrahens inferior* is a strong muscle which arises from the cervical fascia, where it becomes incorporated with the tendon of origin of the trapezius, close to its attachment to the back of the skull. The fibres pass outward and forward, and are inserted into the middle of the upper border of the cartilage of the ear. When in action, it pulls the ear directly toward the side of the skull.

2. *Retrahens superior* arises from the cranial aponeurosis below the origin of the cutaneous muscle of the back of the skull. The fibres pass downward and outward, and are inserted into the cartilage of the ear below and in front of the insertion of the preceding muscle. When it acts, it elevates at the same time that it draws the aural cartilage to the side of the skull.

3. *Retrahens anterior* arises by means of a broad, flattened tendon from the same aponeurosis which gives attachment to the retrahens inferior, by which muscle it is concealed. The fibres, separating so as to form distinct muscular slips, pass obliquely forward and downward, to be inserted into the back of the aural cartilage in front of the retrahens superior. When this muscle acts, it elevates the cartilage of the ear at the same time that it approximates it to the side of the head.

4. *Retrahens internus* is the largest of the muscles of the ear. It is broad and flat, and arises from the aponeurosis which gives origin to the retrahentes inferior and anterior, both of which muscles conceal the attachment of the internus. Its fibres pass directly forward, and are inserted into that margin of the cartilage which bounds the external meatus posteriorly. When it acts, the muscle will tend rather to widen the auditory meatus than alter the position of the cartilage with reference to the head, inserted as it is so close to the fixed point of the aural cartilage, where it is attached to the side of the skull.

The second group includes two muscles:—

1. *Attrahens superior* consists of two portions—the *upper* of which arises from the temporal aponeurosis above the zygoma. The fibres converge as they pass obliquely downward and backward, and are inserted into a well-marked projection of the aural cartilage immediately in front of the external auditory

meatus. The *lower* portion arises from the external surface of the zygoma, and passes directly backwards to be inserted into the anterior margin of the cartilage of the pinna immediately below the insertion of the first portion of the muscle. In action, the upper part of the muscle will pull the cartilage forward and upward, whilst the lower will pull it directly forward.

2. *Attrahens inferior* arises by a narrow tendon from the root of the zygoma immediately in front of the auditory meatus. The fibres of the muscle arch over the fibrous roof of the meatus, and are inserted into the anterior extremity of the upper margin of the aural cartilage. When in action, this muscle will tend to diminish the aperture of the external meatus.

The third group includes two muscles:—

1. *Attollens superior* arises from the cranial aponeurosis above the ear, its origin being closely related to that of the posterior belly of the occipito-frontalis. Its fibres pass obliquely downward and backward, and are inserted into the middle third of the upper margin of the cartilage of the ear. This muscle in acting will direct the cartilage of the ear forward, so as to enable the animal to catch any sound coming from the front.

2. *Attollens inferior* is a muscle of a square shape, the fibres of which pass downward and forward. Its origin exactly corresponds to that of the preceding muscle, and its fibres pass obliquely downward and forward to be inserted into the cranial aspect of the cartilage of the ear, behind the external auditory meatus. In action, this muscle partakes more of the nature of a retrahent than of an elevator muscle of the ear. That is, supposing the ear to have been directed forward by the preceding muscle in the first instance, this muscle tends to approximate it to the side of the skull.

Two intrinsic muscles of the ear remain to be described:—

1. *Trajicus muscle,* which consists of two well-marked fasciculi which arise from the cartilaginous projection in front of the auditory meatus, and, passing backward and upward, are inserted into the upper margin of the cartilage of the pinna close to the insertion of the attollens superior.

2. *Transverse muscle of the auricle* is a muscle of consider-

able size, whose fibres pass across the cranial aspect of the cartilage of the pinna. In this course, they separate the fibres of the retrahens superior into two bundles. The fibres radiate in all directions and form a special muscle of the pinna.

3. MUSCLES OF MASTICATION.

1. *Masseter* arises from the lower margin of the zygomatic arch, from a point immediately below the eye as far back as the insertion of the sterno-maxillaris. The fibres pass obliquely downward and backward, and are inserted into the outer aspect of the rounded angle of the jaw. In relation to its superficial surface is the facial aponeurosis and the duct of the parotid gland, whilst its deeper aspect rests on the temporal muscle.

2. *Temporal muscle* has an extensive origin from the whole of the temporal fossa. The fibres arise from numerous tendinous intersections, which run through the muscle, and, passing obliquely downward and forward, are inserted into the anterior edge and inner surface of the coronoid process of the lower jawbone by means of a powerful tendon. Superficial to the muscle are the temporal artery and temporal aponeurosis, along with the occipito-frontalis muscle.

3. *External pterygoid muscle* arises along with the next muscle from the external surface of the pterygoid bone, in which there is a well-marked ridge extending from the anterior border to near the spheno-palatine canal. From the common tendinous origin the fibres pass off, forming a weak riband-like muscle, which, passing obliquely backward and outward, is inserted into a deep depression on the inner side of the neck of the lower jaw, immediately above the dental foramen.

4. *Internal pterygoid muscle* arises along with the preceding. The fibres form a broad flattened muscle, which, passing backwards and downwards, is inserted into the posterior margin as well as into the inner surface of the ramus of the lower jaw behind the dental foramen.

5. *Buccinator muscle* arises from the alveolar margins of both jaws, as well as from a powerful elastic ligament which extends from the styloid process down to the lower jaw. The fibres pass forward and blend with the other muscles surrounding the opening of the mouth. The muscle is further strength-

ened by the addition of two muscular bundles, which arise from the alveolar margin of the upper jaw between the tusk and molar tooth. Of these the anterior passes downwards and blends with the fibres of the zygomatico-labialis, whilst the other, passing obliquely backwards, is inserted into the ligament which gives attachment to the fibres of the buccinator muscle in the interval between the upper and lower jaws. The muscle is pierced by the duct of the parotid gland.

4. MUSCLES OF TONGUE AND HYOID BONE.

1. *Mylo-hyoid muscle* arises from the inner surface of the ramus of the lower jaw by a linear origin extending from opposite the last molar tooth forward to the symphysis. The muscles of opposite sides are continuous with one another, and have no attachment to the hyoid bone, but form as it were the floor of the submaxillary region. In connexion with the posterior part of this muscle are to be observed a number of fibres which, arising in common with the posterior fibres of the mylo-hyoid, form a flattened band which, passing *behind* the hyoid bone, is inserted into a tendinous bundle which stretches between the roots of the great cornua of the hyoid bone. The function of this band seems to be that of limiting the backward motion of the hyoid bone, and confining it within the sling formed by the mylo-hyoid muscles of opposite sides.

2. *Genio-hyoid muscle* is about two inches broad, and extends from the back of the symphysis of the lower jaw backwards, to be inserted into the posterior aspect of the body of the hyoid bone.

3. *Genio-glossus muscle* is the largest of the lingual muscles. It is triangular in form, and is attached by its anterior extremity to the whole depth of the symphysis of the jaw. From this the fibres pass off, the upper almost vertically, whilst the lower are almost horizontal, and the intermediate having different obliquities between those two sets of fibres. The muscle is inserted along the whole length of the under surface of the tongue, as far back as the hyoid bone, to which, however, none of its fibres are attached.

4. *Hyo-glossus lateralis.*—The muscle which I have so named to distinguish it from the hyo-glossus anterior corre-

sponds to the hyo-glossus of human anatomy. It is a broad flattened muscle, and arises from the outer surface of the upper half of the great cornu of the hyoid bone. The fibres pass obliquely forward and upward to blend with the other muscles forming the lateral margin of the tongue. Beneath it lie the lingual artery and vein.

5. *Hyo-glossus anterior*, to the action of which with reference to the pharyngeal pouch I have already referred, arises from the anterior sharp margin of the body of the hyoid bone, the muscles of opposite sides being in contact at their origin. Each muscle is thin and riband-like, and passes obliquely upward, forward, and outward, to be inserted into the lateral margin of the posterior portion of the tongue. In action these muscles diminish the depth of the pharyngeal pouch.

6. *Stylo-glossus* is a very delicate muscle. It arises from the apex of the styloid process, and passes downward and forward, crossing the insertion of the hyo-glossus lateralis, to be inserted into the side of the tongue in front of that muscle.

7. *Digastric muscle* is a broad fleshy muscle, and arises from the process which projects backward from the styloid process, as also from the surface of bone at the root of the latter. It narrows as it descends, having a broad tendinous intersection about its middle, and is inserted into the lower border of the rounded angle of the lower jaw. On its superficial surface is the external carotid artery, whilst its deeper surface rests on the parotid gland.

Mayer mentions the presence of a *stylo-hyoid* muscle in the elephant, but such I could not distinguish as a muscle distinct from the digastric.

5. MUSCLES OF PHARYNX.

1. The *constrictor muscles* of each side of the pharynx cannot be separated from one another, but form a continuous muscular sheet on each side, attached from before backward to the whole length of the great cornu of the hyoid bone, to the lateral aspect of the thyroid cartilage, and lastly by a small slip to the lateral aspect of the cricoid cartilage. These different portions pass with various obliquities upward to the middle line to become continuous with the corresponding fibres of the opposite

side, and complete the tube of the pharynx. The posterior fibres have the greatest obliquity, and thus gradually verge into series with the straight fibres of the œsophagus.

2. The *stylo-pharyngeus* muscle is very small in size. It arises from the posterior edge of the styloid process, as well as from the angle formed by it with that process of bone which projects backward from it. It passes downward and forward, and is lost in the side of the pharynx.

6. MUSCLES OF THE SOFT PALATE.

Of these there is only a single one on each side,

The *palato-pharyngeus*, which passes backward from the free margin of the soft palate, and is lost in the interior of the pharyngeal wall. It is a well-developed muscle.

The other muscles of the soft palate—namely, the levator palati and tensor palati—are absent, as is also the palato-glossus, the place of which, in front of the tonsil, is occupied by a large fold of mucous membrane, before referred to, which projects free into the region of the fauces.

Mayer describes a circumflexus palati as being present. This was certainly not the case in my specimen.

SALIVARY GLANDS.

Mayer states that in the elephant the *submaxillary* as well as the *sublingual* glands are present. I failed to ascertain the presence of any of the salivary glands, with the exception of the *parotid*. This, which measures eight inches in length by five in breadth, is lodged in the interval between the lower jaw and the temporal bone. The duct passes off from its anterior margin, and, running forward under cover of the facial aponeurosis, pierces the buccinator muscle, to open into the cavity of the mouth.

The other glandular bodies met with in the head of the elephant, such as the thyroid and temporal glands, have been described with sufficient accuracy by Mayer.

NOTES OF A REMARKABLE CASE OF PHARYNGEAL DIVERTICULUM. By M. WATSON, M.D., *Professor of Anatomy in The Owens College, Manchester.*

ALTHOUGH cases in which diverticula connected with the pharynx or œsophagus have been reported from time to time by various authors, these, so far as I can ascertain, have been uniformly of small size, and in none of them is there any approach to the peculiarity of characteristics of the case which I am about to report, and which would therefore appear to be altogether unique; at least in the works of none of the authorities on such subjects, such as Meckel, St Hilaire, or Förster, is there any mention, among the various deviations from the normal to which the œsophagus is liable, of any at all comparable to those of the case here figured.

The body in which it occurred was that of an adult male, sent during the Summer Session, 1874, to the Anatomical Rooms of the Edinburgh University for purposes of dissection.

Upon removing the skin, superficial and deep cervical fasciæ covering the anterior triangular space of the right side of the neck, a muscular structure was seen to extend downward from beneath the tendon of the digastric muscle, which crossed it superficially, as far as the interclavicular notch of the manubrium sterni. This, on closer examination, proved to be a tube with muscular walls, which in the upper part of its course lay directly over the interval between the external and internal carotid arteries, whilst its lower half lay parallel to the anterior border of the sterno-mastoid muscle, and rested on the sterno-hyoid and the sterno-thyroid muscles.

The tube terminated inferiorly in a dilated cul-de-sac, which on being cut into discharged a quantity of grumous material, similar to that found in the cavity of the mouth, as also in the œsophagus. On tracing it upward from the point of crossing of the tendon of the digastric muscle, the tube was seen to pass directly inwards, so as to reach the pharyngeal wall, which it pierced above the level of the stylo-pharyngeus muscle, and opened by a narrow slit like orifice on the free margin of the posterior pillar of the fauces, immediately behind the tonsil. The slit-like opening was not more than one-eighth of an inch in length, and its margins were so closely in contact, that the entrance into it of solid particles from the cavity of the mouth must have been almost entirely prevented. As the tube entered the wall of the pharynx, it passed between the external and internal carotid arteries, and was crossed superficially by the stylo-glossus and stylo-pharyngeus muscles. In relation to its deeper aspect were the glosso-pharyngeal and hypoglossal nerves, along with the stylo-hyoid ligament, as these crossed from without inwards towards the middle line of the neck. It will thus be observed that the tube intervened between

Dissection of the side of the neck of the subject in which the Pharyngeal Diverticulum here described occurred.

the stylo-pharyngeus muscle and the glosso-pharyngeal nerve, which in the normal condition of the parts are closely applied to one another. The diverticulum itself increased in calibre from above downwards, so that whilst at its upper extremity a crow-quill could with difficulty be introduced, at its lower a pencil could readily be passed along the lumen of the tube.

Vessels and Nerves.—Two arterial branches of considerable size were supplied to the tube, one from the occipital, and the other (shown in the woodcut) from the inferior thyroid artery. Several small nerve-twigs were given off by the glosso-pharyngeal as it crossed behind the tube, and were distributed to the walls of the latter.

Structure.—The tube itself was composed of a muscular and a mucous coat. The former consisted of only a single layer of fibres arranged parallel to the long axis of the tube, the circular fibres met with in the other portions of the alimentary canal being altogether deficient. The fibres were, for the most part, of the red striated description. The mucous lining resembled closely that of the œsophagus, being thick and tough, whilst its free surface was covered with a scaly epithelium similar to that found in the œsophagus. The presence or the absence of glands in this coat could not be ascertained by reason of the age of the specimen.

Remarks.—There is considerable difficulty in giving a satisfactory explanation of the presence of this extraordinary diverticulum. Its extent is such, and the opening of communication between it and the pharynx is so small, as at once to exclude the idea that it owes its origin to a hernial protrusion of the mucous surface of the latter. The position of the pharyngeal opening, situated as it is between the lower jaw above and the stylo-hyoid ligament below, points to some modification in the closure of the first post-mandibular visceral cleft of the embryo; but as to what the peculiar circumstances of the intra-uterine existence of this particular individual were which occasioned such a deviation from the usual condition of the parts as we have before us, is difficult to conjecture, more especially when it is borne in mind that our knowledge of the different stages of the development of the visceral arches and clefts is as yet much too limited to enable us to advance anything but a hypothetical explanation of the case now reported.

ON THE POSITION OF THE HEART'S IMPULSE, IN DIFFERENT POSTURES OF THE BODY, based upon Chest-rule measurements, taken by Mr W. A. PATCHETT, *Resident Medical Officer to the Manchester Workhouse Hospital.* By ARTHUR RANSOME, M.D., M.A.

WHEN it is remembered how often it is necessary in Clinical Medicine to observe the position of the heart's impulse, with a view to determine the presence or absence of cardiac disease, or to record its progress, the importance of ascertaining its normal position, and its healthy variations due to changes in posture, will be at once conceded—and it might fairly be anticipated that observations undertaken with these objects might well lead to interesting collateral results. It is therefore somewhat surprising to find how few have been the observations on the subject. It is true that anatomists have stated in general terms the usual impulse-site, but no variations are recorded.

Thus in Quain and Sharpey's *Anatomy* it is stated that "the heart's apex strikes the walls of the chest in the space between the cartilages of the fifth and sixth ribs, a little below the left mamilla." Dr Sibson gives the point "between the fourth and fifth or the fifth and sixth ribs," and Dr Walshe, in more exact terms, states that it "beats in the fifth interspace and somewhat against the sixth rib, about mid-way between the vertical line of the nipple and the left border of the sternum" (*Dis. of Heart*, 4th ed. p. 18). Piorry on the other hand remarks that "in some individuals in health, the heart-beat is raised three, four, or five centimetres higher than in the others," that "in some, it may be found three centimetres to the right of the sternum, in others three or four centimetres to the left of its ordinary state," and though he gives no proofs of his statement, he believes it varies with age, sex, build, constitution, proportion of blood in the organism and "a crowd of other circumstances." *Plessimétrisme*, p. 379. Still fewer records can be found of the degree of mobility of the impulse in different positions of the body. Dr Quain (p. 1102) simply says that the heart "comes more extensively into contact with the anterior walls of the chest when the body is in the prone posture, or lying on the left side,"—and Dr Walshe that "changes of posture elevate, depress, throw it upwards or backwards,"—or again, "the heart falls downwards somewhat (if its substance be weighty the fall may equal an inch) in the erect attitude and comes more forward than in decumbency. Changing the posture in decumbency from the right to the left side will carry the heart an inch, or even more, to the right or left of the position it occupies when the individual lies on the back." P. 9.

But it will be observed that nothing is here said as to the extent to which the motion of the body affects the position of the impulse.

The effect of different diseases of the heart upon the impulse-site is indeed clearly pointed out by this acute observer, and even in that of some non-cardiac disorders; thus he notes the raising of the apex-beat in severe hæmorrhage, and the lowering of its level after a case of typhoid fever, but even Dr Walshe gives no exact measurements on this point.

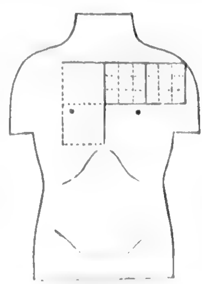
It is probable that one cause of absence of information has been the difficulty of localizing with sufficient definiteness any alterations in the site in question. It is not easy to describe in words the extent to which the impulse gravitates downwards or slantwise, or from side to side, this can only be done satisfactorily by means of ordinate measurements, vertically down the central line of the sternum, and horizontally at right angles to this line.

I have recently proposed the employment of a simple instrument, 'the chest-rule[1],' in order to perform these and other measurements, and Mr Patchett, the resident medical officer to the Manchester Workhouse, has, with the help of this rule, kindly made a number of observations upon which I will now make some comments.

The measurements relate to 51 individuals, they have been made with great care, and are very accurate so far as they extend; they are perhaps as yet too few in number to found upon them any final conclusions, but they are an important contribution to the records on the subject. It is indeed probable that subsequent investigation will only confirm the chief results.

[1] The chest-rule consists of a framework of the finest spring steel, so arranged as to form a rectangular parallelogram, 6 inches long, by 3 in width, and divided into 18 squares of exactly one inch length of side. Owing to its lightness and flexibility it may easily be carried in the note-book, and may be readily applied to the chest, adapting itself to inequalities on the surface.

It is used as is shewn in the annexed diagram-figure, and not only facilitates accurate noting, but may be employed for making numerous measurements both in health and disease. It is manufactured by Messrs J. and W. Wood, King Street, Manchester.



Many of Quetelet's famous measurements of the average dimensions of the human frame were the result of still fewer observations, and yet they were found to be accurate by those who followed him. Even if the tables which follow are insufficient to afford trustworthy averages they at least give the extreme measurements as met with amongst the persons examined, and these will be found to present some very interesting points for remark.

In one sense only are the examples selected—that is, they are drawn from the class to be met with in a workhouse hospital, and therefore represent neither the strongest nor the healthiest of their kind ; otherwise as may be seen they were taken without discrimination of height or make. It may be stated however that cardiac cases were purposely excluded, since it was deemed desirable before passing to this class of cases, that the ordinary standard amongst other sick persons should be ascertained. Moreover, in order to obtain any practical result from such measurements, in cases of heart disease, it would be necessary to accompany them with careful notes of other physical signs and with some history of the symptoms.

The method employed in taking the measurements, was to ascertain by careful touch the position on the chest-wall, where the strongest beat of the heart was to be felt, and at this point a mark with ink, or what is better, coloured collodion, was made. This search was first made in the recumbent posture on the back, next when the patient was sitting or standing up, then when he was lying on the left side, and finally when he lay on the right side. It will be found from the tables that the last-named observation was often doubtful and therefore omitted, and as might have been expected the omissions of this observation are most frequent in the larger and stronger made of the subjects. After each of these points had been ascertained and marked with the pigment, it was very easy afterwards to measure their ordinate distance, first along the vertical line down the centre of the sternum (x) and second along a line through the point at right angles to the vertical (y).

The following are the results obtained.

CHEST-RULE MEASUREMENTS ON THE HEART'S IMPULSE-SITE (IN INCHES).

No.	Length of Sternum.	Position of Nipple.		Position of Heart's Impulse. (Males.) On Back.		Upright.		On Left Side.		On Right Side.		Age.	Duration of Decumbency.	Disease.
		X.	Y.	X.	Y.	X.	Y.	X.	Y.	X.	Y.			
1	4¼	4	3	4½	2¼	4½	2½	4	4	4	1	11	4 weeks	Abscess
2	5	4	3	4¾	2½	5	3	5	5	5	1½	10	1 week	Scarlet Fever
3	5	4	3	4¾	2¼	5	2½	4¾	4	4¾	1	12	....	Ophthalmia
4	6	5	3	6	2	6	2½	6	3½	6	1½	14	....	Ophthalmia
5	6	5	3	6	2	6	2	6	4	6	0	31	2 weeks	Ch. Bronch.
6	6	4	3	5	3	5¼	3¼	5	4½	5	2	16	10 days	Phthisis
7	6	5	3	6	2	6	2¼	6	4	6	1	16	3 weeks	Phthisis
8	6½	4½	5	6	4	6¼	4	6¼	5	6	3	43	3 months	Ulcer of Leg
9	6½	4½	5	6	4	6¼	4	6¼	5	6	3	64	2 weeks	Pneumonia
10	6½	4½	5	6	4	6¼	4	6	5½	6	3	18	1 week	Catarrh
11	6¼	5	3¼	6¼	2¾	6¼	3	6¼	4½	6	1	22	1 month	Phthisis
12	6¾	......		5	3	...	...	5	4¼	5½	½	18	14 days	Fist. in Ano
13	7	4½	4½	6	4	6½	4	6¼	5	6	2½	24	1 week	Fist. in Ano
14	7	4½	3	6	2	6	2	6	4	6	1	25	1 week	Orchitis
15	7	5	3	6½	2	6½	2	6	3	Uncertain.		50	1 month	Bright's Dis.
16	7	5	4	6	4	6½	4¼	6	5	6	2	20	....	Rheumatism
17	7½	5	3	6	2½	6	3	6	4½	6	0	35	2 days	Rheumatism
18	7½	5	3½	7	2	7½	2¼	7	5	7	0	30	2 days	Rheumatism
19	7½	5	4½	6½	3½	7	4	7	5½	6½	2	35	2 weeks	Rheumatism
20	8	4	4½	4¾	4½	5½	3	6	5	6	2	33	3 months	Phthisis 1½ years
21	8	4	4½	4¾	4½	5½	4¾	6	5	6	2	74	21 days	Ch. Bronch.
22	8	4½	4½	5	4½	5½	4½	5	6	5	2½	26	3 months	Ulcer of Leg

23	8	5 . 3	6½ . 2	6½ . 2¼	6 . 4	... .	20	14 days	Phthisis
24	8	5 . 3½	7 . 2	7½ . 2¼	7 . 5	7 . 1	40	14 days	Ulcer of Leg
25	8	5 . 4	6 . 3	6½ . 3	6½ . 4	6 . 2	30	14 days	Bronchitis
26	8	5½ . 3½	6 . 3	6 . 3	6 . 4½	... .	48	10 days	Ch. Bronch.
27	8	6 . 3	7 . 2½	7 . 2¾	6½ . 4½	... .	24	7 days	Ulcer of Leg
28	8	6 . 4	7 . 3	7 . 3	7 . 5	7 . 1	35	6 weeks	Hemiplegia
29	8	6 . 4	7 . 4	7¼ . 4½	7 . 5½	7 . 2	40	14 days	Ch. Bronch.
30	8	6 . 4½	8 . 3½	8 . 3½	8 . 5	8 . 1	74	14 days	Ch. Bronch.
31	8	6½ . 3½	7½ . 2½	7½ . 2¾	7 . 5	7 . 1½	30	21 days	Phthisis
32	8¼	......	6¼ . 2¼	7 . 3¼	... ...	... .	33	28 days	Crushed Leg
33	8½	......	6½ . 2¾	7 . 2¾	6 5	6¾ . 1	35	28 days	Ch. Album.
34	8¾	......	5½ . 3	5¾ . 3	4¾ . 4¾	5 . 1½	21	14 days	Ret. of Urine
35	9	......	6 . 3	7 . 3	... ...	... .	45	1 month	Fract. Leg
36	9	......	6 . 4½	7 . 4½	6¼ . 6¼	6 . ½	39	3 months	Ch. Alb.
37	9	6 . 3½	7½ . 2½	7½ . 3	7¾ . 5	... .	30	1 day	Rheumatism
38	9	6 . 4	8 . 3	8 . 3½	8 . 5	... .	58	....	Ch. Bronch.
39	9	6 . 4	6 . 4	7 . 5	7 . 7	... .	59	1 week	Ch. Bronch.
40	9	6 . 4	7½ . 3	7½ . 3	7 . 5	7 . 2	49	4 weeks	Ch. Bronch.
41	9	6 . 4	7 . 3	7½ . 3	7 . 5½	... .	28	3 weeks	Ulcer
42	9	6 . 4	7 . 3½	7 . 4	7 . 7	7 . 3	30	1 week	Bronchitis
43	9	6 . 4	7 . 4	7 . 5	7 . 7	7 . 2	30	3 weeks	Ch. Bronch.
44	9½	6 . 4¼	7 . 4	7 . 4½	7 . 7	7 . 2½	35	9 days	Rheumatism
45	9½	6 . 4	7 . 3	7 . 4	7½ . 7½	7 . 2	70	14 days	Ulcer of Leg
46	9½	6½ . 4	7½ . 3	8 . 4	7 . 6	... .	33	7 days	Rheumatism
47	10	6½ . 4	8 . 3	8 . 3½	8 . 5	8 . 2	35	Not in bed.	Ch. Bronch.
48	10	6½ . 4½	8 . 3½	8 . 4	8 . 6	8 . 1½	35	7 days	Syphilis
49	10	7 . 4½	8½ . 3½	9 . 4	8½ . 6	... .	60	21 days	Ulcer of Leg
50	10	7 . 5	8 . 3	8½ . 3	8 . 5½	8 . 1	40	21 days	Ch. Bronch.
51	10	7 . 5	8¾ . 4	9 . 4½	8¾ . 6	8¾ . 1½	43	2 days	Rheumatism

The length of the sternum has been taken as a guide in the arrangement of these cases, and though, as may be judged from the tables, this bone varies much in length in proportion to the other dimensions of the chest, yet it is probably as good a standard as could be chosen.

The position of the left nipple is also given, but this varies even more than the length of the sternum, varying in individuals with the same length of sternum, both in its vertical and horizontal ordinates. Thus in the group of cases with eight inches length of sternum, the extreme vertical ordinates of the nipple are 4 and $6\frac{1}{2}$ in., and the horizontal ordinates vary from 3 in. to $4\frac{1}{2}$ in.

The relation of the heart's impulse-site to the nipple in the supine posture, varies from a position immediately under this point, to 1 inch or $1\frac{1}{2}$ inch nearer to the median line of the body, but it is noteworthy that 6 out of the eight cases in which it falls vertically under the nipple, were subject either to chronic bronchitis or phthisis, and it would therefore be important to know whether emphysema or any other lesion of the lung accounted for this, probably abnormal, situation.

The mobility of the impulse-site in different postures of the body varies considerably in these cases. The difference in its position is greater in the change of posture from side to side than in that from the lying to the upright position. In many cases (20 out of the total number) its level is the same in the upright and in the recumbent posture, and in the remainder it varies from $\frac{1}{4}$ inch to 1 inch. In 9 cases it is lowered $\frac{1}{4}$ inch, in 12, $\frac{1}{2}$ inch, in 3, $\frac{3}{4}$ inch, and in three 1 inch. The size of the individual does not seem to make much difference in this regard, since there is as much alteration in the level of the impulse in the small as in the larger made men. One of the cases in which a fall of 1 inch occurs is in a man æt. 59, with a breast-bone 9 inches long, who suffered from chronic bronchitis. It seems possible that some unnoticed hypertrophy of the heart may have existed in this case, but in the other two there is no suspicion of this disorder. Of the three cases in which it dropped $\frac{3}{4}$ inch, one was a case of phthisis, another of chronic bronchitis, aged 74, and the third a man aged 33, suffering from a crushed leg.

It is interesting to observe that in most cases (i.e. in 60 per cent.) there was a small movement of the impulse to the left as the patient rose to the upright position, and in some instances this occurred even when there was no sinking in the level of the heart. The extent of this sidelong movement varied from ¼ inch to 1 inch along the horizontal ordinate. In one case only (No. 20) was there a movement of the impulse to the extent of 1½ inches towards the right side; and as this man was the subject of phthisis, there might well have been some adhesions or loss of lung-substance to account for the exception.

The extent of the movement of the impulse-site from side to side is not, as I have before mentioned, always discoverable, since in some cases, when the patient lay upon the right side, the heart-beat was under the breast-bone[1]. In twelve out of the 51 cases the extent of the lateral movement was thus left uncertain; but in the remaining 39 it was traced, and was, in most instances, found to be much larger than could have been anticipated from the remarks which have just been quoted.

The mean extent of the movement in the whole number of cases was about 3¾ inches, the maximum was 5¾ inches, and the minimum two.

As might have been anticipated, the degree of movement increased, in the main, with the length of the sternum; in other words, with the size of the chest: thus, the mean of the 18 cases, with less than 8 inches of sternum, was 2·8 inches, that of the eleven having this bone 8 or 9 inches long was about 3·6 inches; the remaining 10 possessing a lateral movement of over 4 inches.

The case (No. 36) having the maximum motion of 5¾ inches belonged to the last group. It was one of chronic albuminuria, and the patient had been confined to bed for 3 months; the length of his sternum was 9 inches: here again there may have been some cardiac hypertrophy. Of the 4 cases with the

[1] In this statement it may be noticed that the term "apex-beat" has been avoided. It involves the theory that the heart's impulse is always occasioned by the impact of its apex against the chest-wall, but as Dr Walshe has pointed out the chief vibration of the chest-wall is sometimes produced by its base, and in many of the cases recorded here, it was certainly not the apex that was felt beating under the finger.

minimum movement of 2 inches, three came within the first group, and one had a breast-bone 8 inches long; this last was a case of bronchitis in a man 30 years of age.

In most instances (27 cases) when the body was turned upon the left side, the heart's impulse remained at the same level that it had in the supine posture; but it is interesting to note that, in a fair proportion (21 cases), the heart-beat was as low as in the erect position; in 4 cases it sank even lower than this, and in 22 it was found at a slightly higher level.

It would be impossible to draw from these cases of disease any trustworthy conclusions as to the usual extent of the motion of the impulse-site in health; and their number is still far too small for us to gather much information as to the variations introduced by different disorders.

It is, however, already evident, that such variations do occur, and we may reasonably expect that further investigations of a similar nature will enable us to trace some definite relations between the disease and the mobility of the heart. It is at least highly probable that conditions affecting the expansion of the lungs, or permitting the relaxation of the parts composing the ligaments of the heart, would manifest themselves in observations such as those now before us.

It is also important to notice what emphasis these measurements give to the caution that in all observations upon the heart's impulse in cardiac disease, care should be taken always to place the patient in the same posture at each observation, otherwise most serious errors might easily be made.

A DESCRIPTION OF THE CEREBRAL AND SPINAL NERVES OF RANA ESCULENTA.—By the Baron Armand de Watteville, M.A., *Lond.*

The following pages are but a fragment, the partial result of a series of dissections conducted last winter at the South Kensington School of Science, and at University College, by the kind permission of Profs. Huxley and Sanderson. However humble in their aim, and defective in their execution, I cannot allow them to pass through the press without acknowledging my deep gratitude to both the distinguished *savans* just named, for the encouragement given and the kindness shewn to me throughout my work.

My aim in publishing the present paper is simply to supply some facts to the comparative anatomist, and offer a guide to the practical physiologist in his study of that serviceable, but ill-remunerated animal, the Frog[1].

Table of the Muscles supplied by the Cerebral and First Spinal Nerves.

(Ecker's nomenclature is followed as being the most convenient.)

Rectus Inferior	III.
„ Superior	III.
„ Internus	III.
„ Externus	VI.
Obliquus Superior	IV.
„ Inferior	III.
Retractor Bulbi	VI.
Levator Bulbi	V. (orbito-nasal).
Intermaxillaris	V. (orbito-nasal).

[1] I much regret that circumstances did not allow the illustrations which were to accompany the present description to be brought out in time for the present number of the Journal. Their publication is, I trust, only retarded. In the meanwhile the student will derive much help from Ecker's figures of the nerves of the frog in his *Icones Physiologicæ;* and of the bones and muscles in the first part of his *Anatomie d. Frosches*—a work which is unfortunately unfinished. The illustrations in Schiess' paper are as unsatisfactory as the text is inaccurate.

Lateralis Narium	V. (orbito-nasal).
Digastricus	VII.
Temporalis	V. sup. max.
Pterygoideus	„
Masseter	„
Submaxillaris	„
Submentalis	„
Geniohyoideus	1st spinal.
Sternohyoideus	„ „
Omohyoideus	„ „
Genioglossus	„ „
Hyoglossus	„ „
Petrohyoideus Anterior ...	IX.
„ 1	X. (petrohyoid).
„ 2	X. (petrohyoid).
„ 3	X. Recurrent Laryngeal.
Sternomastoid	XI.
Interscapularis	X. (scapular).
Levator anguli scapulæ ...	1st spinal.
Intertransversarii capiti ...	1st spinal.
Longissimus dorsi (anterior part)	„ „
Retrahens scapulæ	„ „
Transverso-scapularis tertius	„ „

List of writers to be consulted:

Volkmann. *Müller's Archiv*, 1838. p. 70.
Fischer. *Amphibiorum Nudorum Neurologia.* Berol. 1843. 4to.
Hjelt. *De nervis Cerebralibus &c. Bufonis Cineri.* Helsingfors. 1852. 8vo.
Schiess. *Specielle Neurologie d. Rana Esculenta.* Bern et St Gallen. 1857. 4to.
Vogt. *Müller's Archiv.* 1839. p. 39.
Vogt. *Neue denksch. d. Alg. Schw. Ges. f. d. Ges. Naturwiss.* IV. Neufchatel. 1840.
Wyman. *Smithsonian Institute,* V.
E. H. Weber. *Anat. Comp. Nerv. Symp.* Lipsiæ. 1817. 4to.
Bidder and Volkmann. *Die Selbstandigkeit d. Nerv. Symp.* Lip. 1847. 4to.
Küttner. *Dissertatio de orig. n. s. Ran.* Dorpati. 1854.
Ecker. *Icones Physiologicæ.* Leips. 1851—59.
Stannius. *Zootomie: Amphibien.* Berlin. 1854. 8vo.
Fürbringer. *Jenaische Ztschr. f. Med. u. Nat. wiss.* March, 1873.

Cerebral Nerves.

We shall, for the sake of convenience, divide the cerebral nerves into three groups:

1. The first group includes those nerves which are destined to the organs of the higher senses—olfactory, optic, and auditory. These nerves are characterized by their softer consistence, and are distributed to the parts they supply after a very short course. They will be best considered along with the description of the organs themselves.
2. Nerves included in the trigeminus group, *i.e.* the third, fourth, fifth and sixth pairs, along with the seventh. The last three enter into the composition of the Gasserian ganglion.
3. The vagus group, including the ninth, tenth, and eleventh pairs.

All the cerebral nerves are characterized by taking their origin from the encephalon, and by being, during the first part of their course in the cranium, directed forwards to their foramina of exit.

Second Group of Cerebral Nerves.

We have seen that three of this group—the trigeminus, abducent, and facial—concur in the formation of the Gasserian ganglion. Of the remaining two, the oculomotor enters into close relation with the ophthalmic, whilst the pathetic runs in a common sheath with a branch of the ophthalmic, but without intermixture of fibres. All the nerves of this group supply the head with motor and sensory fibres. Their branches may be arranged in four categories—orbital, nasal, palatine and maxillary. The seventh pair sends also a large cutaneous branch to the sternal region. As will be seen further on, the cephalic portion of the sympathetic merges into the Gasserian ganglion, and so enters into close relation with the various branches given off by it.

Third Pair, or Oculomotor.

The oculomotor nerve arises as a round bundle from the crus cerebri, covered by the hypophysis. It thence runs at an angle of about 45° forwards and outwards towards a foramen in the cartilaginous wall of the cranium, situated immediately in front of the Gasserian ganglion.

Upon leaving the skull it enters the orbit between the pterygoid and retractor-bulbi muscles, and divides into two branches, which closely embrace the ophthalmic nerve.

(a) The *Superior Branch* passes over the ophthalmic and ascends under cover of the rectus superior, in which it ends.

(b) The *Inferior Branch* enters into close relation with the ophthalmic, with which it apparently exchanges fibres. Passing underneath that nerve it continues its course between the retractor and levator bulbi muscles to the inferior surface of the eyeball, where it supplies the inferior and internal recti, and ends in the inferior oblique.

(For the "ciliary" nerve see below, under sixth pair.)

Fourth Pair, or Pathetic.

The fourth nerve arises from the optic lobes. It then winds downwards and forwards around the lobes, and reaches the inferior surface of the encephalon. It then runs forwards, crossing the third, to a small foramen in the cartilaginous wall of the cranium, above and behind that of the second. It enters the orbit among the fibres of the superior rectus. Its course lies first to the inner, then to the outer side of the ophthalmic, over which it passes to supply the superior rectus.

As mentioned above, the fourth nerve is usually placed in a common sheath, with a branch of the ophthalmic during its course in the orbit. But there appears to be no interchange of fibres between the two nerves. Occasionally the pathetic passes through the branch of the fifth.

Fifth Pair, or Trigeminus.

The fifth nerve arises from the lateral part of the medulla oblongata behind the optic lobes. This root is single, and no distinct motor part can be made out. Running for a short distance forwards and outwards, the nerve expands into a considerable *ganglion of Gasser.* This is placed in a depression in the lateral wall of the cranium, leading to a large foramen. This foramen is almost entirely surrounded by the prootic, the ring being completed, in front, by cartilage. This cartilage sometimes is found ossified and contains the foramen of the third nerve. The Gasserian ganglion is of considerable size, oval, and of a bright yellow colour. It is closely surrounded by the usual chalk crystals and pigmented fibrous tissue; the carotid artery is in close relation with it as it enters the skull through the above-mentioned foramen.

As we have seen, the Gasserian ganglion of the frog exhibits some peculiarities; for besides the fifth it receives three other nerves, viz. the sixth, seventh, and cephalic portion of the sympathetic.

It will be perhaps convenient to describe the origin of the sixth and seventh at once.

The sixth nerve is a very slender filament arising from the medulla oblongata, near the middle line, opposite the "precondyloid" foramen. It thence runs to the inferior surface of the ganglion, which it enters.

The seventh nerve arises immediately in front of the auditory, and remains in contact with it during the first part of its course. It soon separates, however, and bending forwards reaches the external border of the fifth, along with which it penetrates the Gasserian ganglion.

The arrangement and course of these nerves in the ganglion, as far as they can be made out by mere dissection, are as follows: looking at the inferior surface of the ganglion its constituent nerves appear in this order: first the sympathetic, immediately beneath it the sixth, then the fifth and seventh.

The sympathetic presents the usual appearance of a double chain. It splits up into several bundles, which are seen to join the various branches given off by the ganglion.

The sixth divides into two bundles which traverse the ganglion, one of these usually joins the ophthalmic, whilst the other makes its exit independently next to the ophthalmic.

The seventh bends backwards and splits into two bundles, one of which leaves the ganglion as the hyomandibular branch; whilst the other approximates the palatine of the fifth, to which it gives some of its fibres, and is continued as the palatine of the seventh.

The fifth divides into three main bundles, one of which becomes the maxillary nerves; the two others continue their course as orbito-nasal and palatine respectively. All these nerves give fibres to and receive fibres from the substance of the ganglion.

I. *Orbito-Nasal, or Ophthalmic Nerve.*

This nerve arises from the anterior border of the Gasserian ganglion. The first part of its course lies in the orbit: here its direction is forwards and slightly upwards, rising as it advances from the foramen "lacerum" to that in the os en ceinture, through which it leaves the orbit. It lies throughout near the lateral wall of the cranium, to which it is parallel. The nerve lies at first between the origins of the pterygoid and retractor bulbi muscles. Here it comes into close contact with the third nerve, being embraced by its two divisions, as we have seen before. The orbito-nasal then passes over the optic nerve, between it and the rectus superior, and has first to its inner side, then to its outer side, the fourth nerve. The nerve is next placed between the eye and Harderian gland and the lateral wall of the cranium, lying upon the fibres of origin of the levator bulbi, and being covered by the dense fibrous tissue which forms with a fold of skin the upper eyelid. Having reached the anterior corner of the orbit it passes into the nasal cavity through the foramen above mentioned.

During the first part of its course the orbito-nasal gives off the following branches:

(1) *Cutaneous branches.* One of these joins the pathetic in the manner before explained. It is distributed to the anterior half of the upper eyelid. One or two other branches are given off to the skin between the orbit and the nostril.

(2) Branches of minute size seem to terminate in the Harderian gland. For the "ciliary" nerve see below, under sixth pair. In the nasal cavity the orbito-nasal lies between the mucous membrane and the nasal bone. It runs forwards parallel and in apposition to the cartilaginous septum of the nose. At the anterior part of the cavity it makes its exit between the nasal and premaxillary bones, and becomes cutaneous, splitting into a bundle of filaments to supply the integuments of this region.

During its course in the nasal cavity the orbito-nasal nerve gives off:

(1) *A cutaneous branch,* which leaves the trunk close to the "nasal" foramen, and runs at an angle of about 45° across the roof of the cavity to the nostril, behind which it becomes subcutaneous and supplies the integuments about the nostril. One or two cutaneous offsets occasionally pass through the roof of the nasal cavity and supply the integument of the part.

(2) A large *communicating branch* is given off at the anterior extremity of the nasal sac, around which it arches to join the vomerine branch of the palatine. Its distribution will be given below.

(3) *Cutaneous branches* to the premaxillary region, mentioned above.

II. *Supramaxillary Nerve.*

During the first part of its course this nerve is included in a common sheath with the inframaxillary. The two nerves are placed at first upon the anterior surface of the prootic, and are covered by the pterygoid. Next they run forwards and outwards between the latter and the temporal muscle. They thus reach the posterior angle of the orbit, where they become subcutaneous and take different courses.

The supramaxillary keeps close to the posterior and inferior margin of the orbit, between the eyeball and the tympanic bone, and is here covered only by the skin and some tough fibrous tissue. It continues its course downwards and forwards along the external surface of the upper jaw, being subcutaneous, and spending itself as it proceeds in branches to the integuments of these parts.

The supramaxillary nerve supplies branches to the integuments and the mucous membrane of the palate. The following are the most important:

(1) *Supraorbital* branch. This is considerable in size and supplies the posterior half of the upper eyelid and the skin above and behind the orbit.

(2) *Tympanic* branch. Runs under the temporal fascia, which it pierces above the tympanic ring. It supplies branches to the skin behind the ring and the tympanic membrane itself.

(3) *Malar* branches. One of these supplies the skin in front of the ring. Another large branch passes over the tympanic bone, and supplies the skin below it, anastomosing with the former and with the auricular branch of the seventh.

(4) *Inferior palpebral,* to the inferior eyelid and nictitating membrane.

(5) *Communicating branch,* to the palatine, given off at the inferior margin of the orbit. This branch sinks directly downwards between the orbit and maxillary bone, and joins the palatine, as will be more fully described further on.

(6) *Infraorbital* supplying the skin above the maxilla as far as the nostril.

(7) *Maxillary branches* supply the integuments covering the upper jaw, and are divisible into two sets, posterior and anterior, the former running backwards, the latter forwards. Some of the anterior filaments anastomose with the cutaneous branches of the orbito-nasal in the premaxillary region.

III. *Inframaxillary Nerve.*

After it has separated from the supramaxillary the inframaxillary nerve arches backwards over the temporal muscle, passes under the tympanic bone, and behind the tympanic ring pierces the masseter. It descends among the fibres of this muscle and reappears at its insertion into the lower jaw. It is here subcutaneous, and winds round the bone, reaching its internal surface, which it follows closely to the symphysis.

Branches. (1) *Temporal and pterygoid.* Given off whilst the nerve is placed between these two muscles. They either arise separately or by a common trunk.

(2) *Masseteric* filaments are furnished during the course of the nerve among the fibres of the massetes.

(3) *External mandibular* follows the external surface of the lower jaw and supplies the integuments.

(4) *Musculo-cutaneous* branch. This is a considerable offset, and runs inwards, supplying the "mylohyoid" muscle and the skin covering it.

(5) *Cutaneous* branches to the integuments near the symphysis.

(6) *Muscular* branches to the mylohyoid and submentalis muscle.

IV. *Palatine Branch.*

On leaving the Gasserian ganglion this nerve is directed forwards and downwards. It curves round the posterior border of the rectractor bulbi, and then lies between this muscle and the mucous membrane of the mouth, upon which it continues to run with the parasphenoid to its inner side as far as the anterior extremity of this bone. Here the nerve gives off its vomerine branch, and bends sharply outwards. It follows the posterior border of the palatine bone, and is joined, close to the internal surface of the maxilla, by the communicating branch from the supramaxillary.

Branches.

The palatine nerve supplies several offsets *to the mucous membrane* of the mouth.

After its junction with the communicating branch of the supramaxillary it supplies branches to the mucous membrane covering the jaw. These are *posterior* and *anterior.* The former running backwards along the posterior half of the maxilla. The latter runs along the inner surface of the maxilla and premaxilla, where they anastomose with offsets of the vomerine branch.

The *Vomerine branch* runs forwards over the inner extremity of the palatine bone to the vomer, then it passes through a foramen in the bone, reappearing at its anterior edge. Here it sends a few offsets to the neighbourhood of the internal nerves. Continuing its course forwards and slightly outwards, it is joined by the communicating branch of the orbito-nasal, and is distributed to the mucous membrane of the region. Some offsets appear to end in the intermaxillary muscle.

Sixth Pair, or Abducent.

The sixth nerve runs through the Gasserian ganglion parallel with and covered by the sympathetic. It reaches the point of origin of the ophthalmic nerve, and there divides into two branches. The first of these runs outwards along the external rectus, which it supplies. The second runs along with the ophthalmic to a point a little beyond where the third enters in communication with the ophthalmic. Here a nerve is given off, of which a part containing the fibres of the sixth go to supply the retractor bulbi muscle, whilst the rest run onwards closely applied to the ophthalmic artery, and forms a "ciliary" nerve, splitting up into a number of filaments which penetrate the sclerotic about the point of entrance of the optic nerve.

This "ciliary" nerve probably consists of elements of the fifth, along with fibres from the third and sympathetic.

Seventh, or Facial Nerve.

We have seen that the facial nerve divides in the Gasserian ganglion into two bundles, of which one forms the palatine, the other the hyomandibular branch.

(1) *Palatine branch.* This branch arises near the palatine of the fifth, but is separated from it by the carotid artery, which here enters the skull. Its course is very short. It sends several offsets to the posterior part of the mucous membrane of the mouth, and immediately throws itself into the palatine branch of the fifth.

(2) The *Hyomandibular branch* represents the facial proper of man. It lies at first upon the anterior surface of the prootic, and is covered by the temporal muscle. It next turns backwards and passes through the foramen into the tympanic cavity, where it crosses over the columella. At its exit from the cavity it unites with a large branch from the glossopharyngeal. Thus increased the nerve takes an outwards and downwards direction, having in front the posterior wall of the tympanic cavity, and above the sterno-mastoid muscle. It next lies in contact with the thyroid body under cover of the digastric, and in this position splits into its two main branches, mandibular and hyoid, after having furnished the following offsets.

Branches.

(1) *To the digastric.*

(2) *Auricular.* This branch runs forwards under the digastric muscle and becomes subcutaneous at its anterior border, close to the inferior margin of the tympanic ring. Cutaneous offsets are given off:

(a) *Anterior,* to the skin over the jugal bone, anastomosing with branches of the malar of the supramaxillary.

(b) Posterior, distributed to the integuments behind the tympamun.

(c) Descending, passing over the articulation of the jaw, and losing themselves in the integuments of that region.

A. *The mandibular branch* winds round the articulation of the jaw, and runs forwards to the symphysis along the inner surface of the lower jaw, parallel to, but deeper than, the inframaxillary, from which it is separated by a layer of connective and adipose tissue.

B. *The hyoid branch* (sternal) is larger than the preceding. It runs downwards and inwards along the posterior belly of the "mylohyoid," and over the deltoid. It is subcutaneous.

Branches.

(1) *Muscular,* to "the posterior belly of the mylohyoid" (stylohyoid).

(2) *Cutaneous,* to the integuments in the region of the episternum. Volkmann states that on electrical stimulation of the root of the seventh he observed contractions of the air-pouch of the male frog. This implies the existence of offsets from this branch of the nerve to the muscular layer of the pouch.

Third Group of Cerebral Nerves.

This group comprises the ninth, tenth and eleventh pairs of nerves. They unite to form a large ganglion, to which the sympathetic also contributes a considerable offset.

The roots of the ninth and tenth arise close together from the lateral aspect of the medulla oblongata opposite the condyles of skull. They soon unite into a thick bundle as they proceed to the precondyloid foramen.

The eleventh nerve arises by a single root from the antero-lateral aspect of the spinal cord, opposite the body of the first vertebra, a little higher than the root of the first spinal or hypoglossal nerve. It makes a sharp angle with the spinal cord and joins the root of the vagus near the foramen, intimately blending with it. At their exit from the bone the three nerves expand into a large ganglion. The ganglion is placed under cover of the intertransversarii capitis, and is surrounded by a capsule of pigmented fibrous tissue. It is pyriform in shape. Closely connected with its inferior surface the sympathetic lies underneath it. The three nerves occupy in the ganglion from above downwards the reverse order of that which they occupy lineally, *i. e.* uppermost comes the eleventh, then the vagus, and lastly the glossopharyngeus.

Ninth Nerve, or Glossopharyngeus.

The glossopharyngeus leaves the ganglion beneath and somewhat in front of the vagus. Both nerves run together for a short distance, the glossopharyngeus remaining in front. They are placed at first under the intertransversarii capitis, then arch over the origin of the protractor scapulæ. Their direction is outwards, parallel to the petrous bone, to the posterior surface of which they are closely applied. They are covered, partly by the overhanging ridge of the bone, and by the depressor maxillæ muscle.

The two nerves thus reach the posterior border of the petrohyoids, where they separate. The glossopharyngeal passes under the posterior petrohyoid, between it and the levator anguli scapulæ, and reappears through the fibres (usually) of the third petrohyoid, upon which it runs as far as the carotid gland. Here it is parallel to, and in front of, the laryngeal nerve. The nerve makes upon the gland a sharp turn forwards, and passes under the omohyoid and upon the anterior petrohyoid at its insertion into the hyoid bone. It is crossed by the lingual artery, which from this point runs along its outer side to the tongue.

The glossopharyngeal is here covered by the geniohyoid muscle; it continues its course forwards through the notch between the body and anterior cornu of the hyoid bone, thence between the hyoglossus and geniohyoid to the tongue, taking a more inward direction so as to come to lie to the inner side of the hypoglossus. The latter nerve is superficial to the glossopharyngeal during this part of its course. But near the root of the tongue the two nerves lie near one another, both bending sharply backwards as they enter the organ through the triangular space formed by the two halves of the hyoglossus and genioglossus muscles. They are thrown into folds, so as to present a wavy outline, this being a provision to allow for the great extension to which they are subjected when the tongue is extruded.

Branches.—1. *Communicans ad facialem.* This is of large size—as large as the seventh itself,—and is given off close to the ganglion, whence it is directed along the posterior wall of the cranium, to join the seventh at its exist from the tympanic cavity.

(2) A branch is given off near the point where the glossopharyngeus passes under the fourth petrohyoid. It runs downwards between the mucous membrane of the pharynx, to which it sends offsets, and the petrohyoid muscles and hyoid bone. It contributes to form the plexus mentioned further down, under the head of the branch of the vagus.

(3) A branch to the anterior petrohyoid is given off by the former glossopharyngeal as it lies upon this muscle.

(4) Other offsets to the mucous membrane of the pharynx and middle portion of the floor of the mouth are given off by the nerve as it proceeds. The lateral parts of the floor of the mouth are supplied by offsets of the mandibular branch of the seventh, derived ultimately, it is probable, from the communicating branch mentioned above.

(5) As the nerve is about to enter the tongue several branches are given off to the mucous membrane about the symphysis of the mandible.

(6) The glossopharyngeus ultimately expends itself into

filaments to the mucous membrane of the dorsum of the tongue.

Tenth Nerve, or Vagus. Eleventh Nerve, or Spinal Accessory.

After separating from the glossopharyngeus the vagus, containing the fibre of the eleventh, bends backwards and downwards, and follows the posterior edge of the petrohyoideus IV., accompanied by the cutaneous artery and vein. It is covered by the sterno-mastoid. It lies first upon the levator anguli scapulæ, around which it winds, so that further down this muscle covers the nerve. In this position the vagus passes between the hypoglossus and the ascending aorta, and gives off its gastric branches. Still keeping along the petrohyoid muscle, which usually separates it from the laryngeal nerve, the vagus reaches the arch of the pulmonary artery, and splits underneath it into its terminal offsets, and pulmonary cardiac and small laryngeal.

Branches.—(1) The *cutaneous* branch is given off by the vagus close to the ganglion. It runs directly upwards along with the cutaneous artery, and passes between the temporal and digastric muscles to be distributed to the skin, chiefly of the scapular region. Its offsets are (a) ascending, towards the middle line of the back; (b) descending, supplying the skin over the digastric; (c) posterior, accompanying the ramifications of the cutaneous artery.

(2) The *petrohyoid* branch is a short trunk which passes underneath the petrohyoid muscles, where it sometimes forms a ganglion, and splits into fine branches. Two of these run downwards under the second and third petrohyoids, which they supply, and reach the mucous membrane of the pharynx under the lower cornu of the hyoid bone, where they form, with an offset of the glossopharyngeus, a kind of ganglion plexus.

(3) Branch to the interscapularis muscle. This is a very fine offset, which runs backwards upon the levator anguli scapulæ, and ends in the above-mentioned muscle.

(4) *Laryngeal Nerve.* This important branch, the homologue of the "recurrent," runs parallel with the vagus, from which it is usually separated by the petrohyoid IV. It lies

either in front or upon this muscle, and supplies it. Near the inferior cornu of the hyoid bone it winds round the pulmonary artery from above down. It then crosses at a right angle the cornu at its lower third, and sinks between it and the larynx, to which it is distributed, supplying its muscles and mucous membrane.

(5) *Gastric Branches.*—These are usually two in number and of considerable size. They are given off at the point where the vagus passes under the hypoglossal. They reach the stomach by piercing the muscular diaphragm, formed by the insertion of the upper fibres of the internal oblique into that organ. They ramify largely upon its surface, and supply its substance.

(6) *Pulmonary Branches.*—As before mentioned, the vagus splits under the pulmonary artery into several branches. Those destined to the lung accompany the ramifications of the artery to that organ, piercing the diaphragm, and spreading over the anterior and posterior surfaces of the lung.

(7) *Cardiac Branch.*—This branch is usually smaller on the right side than on the left, and runs under cover first of the pulmonary artery, then of the superior vena cava, which it accompanies to the posterior aspect of the sinus venosus. As it proceeds it sends off two or three filaments to the roots of the lungs. Before the cardiac nerves reach the heart they are placed in communication with one another by means of a transverse branch. They then enter the cavity of the auricles, where they are placed upon the septum; the nerve of the right side coming to be in front of the other. They run downwards towards the auriculo-ventricular opening. There they expand into two ganglia, from which filaments ramify into the substance of the heart.

(8) A small superficial laryngeal nerve is given off by the vagus along with the cardiac. This branch passes between the tip of the posterior cornu of the hyoid bone and the mucous membrane of the pharynx. It splits up into numerous fine offsets, which are distributed to the mucous membrane around the external laryngeal opening.

The *eleventh nerve* leaves the vagus close to its scapular branch, and supplies the "sternomastoid" of Ecker—a muscle which Fürbringer identifies as the homologue of the trapezius.

Spinal Nerves.

The spinal nerves are ten in number. They all originate by two roots, anterior and posterior, which run backwards in the vertebral canal towards their respective intervertebral foramina. The lower a nerve arises, the longer its course inside the canal, and the acuter the angle it forms with the cord. Opposite each intervertebral foramen the posterior root expands into a ganglion. The ganglia are of the characteristic yellow colour, and are surrounded by a variable quantity of chalk crystals. Much pigment is found in the fibrous tissue surrounding some of the nerves near the vertebral column, especially the brachial. Each spinal nerve gives off near the intervertebral foramen a posterior branch to the muscles and integuments of the back. The number of each nerve corresponds to that of the vertebra behind which it is placed in the intervertebral foramen, there being no "sub-occipital" nerve.

The spinal nerves may be arranged in the following manner:

First, or cervical division: First spinal nerve (hypoglossus).
Second, or upper dorsal: Second (brachial) and third nerves.
Third, or lower dorsal: Fourth, fifth, and sixth nerves.
Fourth, or lumbo-sacral: Seventh, eighth, and ninth nerves.
Fifth, or coccygeal: Tenth nerve.

First Division of Spinal Nerves.

The anterior root of the hypoglossus is double, being composed of two bundles of fibres arising opposite the first vertebra. The posterior root is very slender, and forms a small ganglion at its exit from the intervertebral foramen. Here the anterior and posterior roots join into one nerve, and come into close contact with the sympathetic, with which they are bound up by some very dense fibrous tissue, and exchange fibres. The hypoglossus is here placed between the intertransversarii muscles and the mucous membrane of the pharynx. In front of it lies the vertebral artery, behind the brachial artery and nerve. It lies upon the sympathetic and the bend of the aorta. It runs downwards under cover of the levator anguli scapulæ, superficially to the ascending aorta. Further it crosses the vagus and laryngeal nerves, the carotid gland being placed between the sternohyoid and petrohyoid muscles. The hypoglossus then makes a sudden curve forwards, and proceeds under the omohyoid and the mylohyoid muscles to the origin of the geniohyoid, between the fibres of which it runs as far as the root of the tongue. Its relations to the glossopharyngeus are as follows: It lies first superficial to, and to the outer side of, it; then, as before mentioned, comes to be placed to its inner side as it curves backwards and upwards to enter the tongue. It ends into filaments to the intrinsic muscles of this organ.

Branches.—(1) Posterior branches are given off close to the intervertebral foramen to the muscles of the neck, viz. the anterior portion of the longissimus dorsi and the intertransversarii capitis.

(2) Offsets supply the following scapular muscles:—levator anguli scapulæ, retrahens scapulæ, and transverso-scapularis tertius. (See Fürbringer, *loc. cit.*)

(3) A communicating branch to the brachial plexus, which either joins the brachial, or, as Fürbringer has shewn, splits into two filaments, one of which joins the supracoracoid, the other the branch supplying the abdominal muscles.

(4) A branch to the sternohyoid and omohyoid (descendens noni) arises from the nerve where it is covered by these muscles.

(5) As the nerve proceeds it gives offsets to the muscles by which it is surrounded, the hyoglossus, geniohyoid, and genioglossus.

APPENDIX.

On the Cervical and Cerebral Portion of the Sympathetic.

The sympathetic chain on either side of the body enters into relation with every spinal nerve by means of thick communicating branches. These are very long in the lower part of the body, but become shorter and shorter higher up, until, as is the case with the brachial nerve, the cord itself of the sympathetic comes into contact with the spinal nerve. This is the case also with the cerebral nerves, as we have seen above.

Between the brachial and hypoglossal nerves the sympathetic splits into two chains, which surround the brachial artery. Having then exchanged fibres with the hypoglossal the sympathetic expands into a large cervical ganglion, the anterior extremity of which reaches almost as far as the ganglion of the vagus.

The sympathetic penetrates into the skull through the precondyloid foramen, and thence runs forwards along the floor of the cranial cavity, under the roots of the eighth and seventh nerves, to the inferior surface of the Gasserian ganglion, into which it sinks and splits up into several bundles of fibres, which go to join the various offsets of the ganglion.

ON PHOCA GROENLANDICA AS A BRITISH SPECIES OF SEAL.—By Professor Turner.

There has been some question amongst naturalists if the Greenland Seal is a frequenter of the British seas and coasts. Seals captured in the Severn, the Thames and the Firth of Forth, have been mentioned as belonging to this species, but as neither their bones nor skins have been preserved doubts have been thrown on their identity. The late Dr Saxby stated in the *Zoologist* for March, 1864, that several Harp Seals were then to be seen in Balta Sound, Shetland, but none of these specimens seems to have been captured. The editors of the new edition of Bell's *British Quadrupeds*[1], referring to these cases, whilst stating "although we are unable to point out any undoubted native specimens in our Museums, the evidence in favour of its occasional occurrence seems too strong to be disregarded," yet admit that "it is not without considerable doubt that we retain the Greenland Seal in the list of British Mammals." During the past summer (1874) a specimen was sent to me for examination, which indubitably establishes the *Phoca Groenlandica* to be an occasional visitor to our shores, and gives it a right therefore to a place in the British fauna. It is to the sagacity of Thos. Gough, Esq., M.R.C.S. of Arnbarrow, Milnthorpe, that we are indebted not only for the determination of the species, but for the preservation of the specimen. Mr Gough has kindly favoured me with the following extract from the *Westmorland Gazette* of Feb. 1, 1868, in which he gave an account of the capture of the animal.

"Capture of a Seal in Morecambe Bay.

"On Thursday the 23rd of January, the Messrs Crossfield shot a seal near the viaduct on the Lancaster and Ulverston Railway, near Arnside. When first discovered its dark-coloured head, alternately bobbing about and ducking under the surface of the

[1] London, 1874, p. 253.

water, was taken for a duck, but a nearer approach soon made known the prize which the marksman had to secure. A discharge of shot wounded the animal severely, and repeated blows on the muzzle and head rendered it a helpless captive. It was conveyed to Kendal on the following Saturday, and was purchased for the Museum of the Literary and Scientific Institution. We had an opportunity of examining the specimen soon after it arrived. Its length was six feet from the tip of the nose to the point of its hind toes, the circumference behind the fore-feet 43 inches: colour of the head dark brown, rather dark on the back, rest of the body grey blotched with brown spots—teeth six incisors in the upper jaw, four in the lower; canines two in each jaw; molars five on each side of each jaw, with prominent conical points slightly lobed at the base, placed in a straight series with moderate interspaces between, in all thirty-four, a number characteristic of the genus Phoca (seal); fore-feet with the second toe rather longer than the first. There are two characters in the above short description, which enable us to determine the species. These are the arrangement of the grinders and the comparative length of the first and second fore-toes. In the common seal (*Phoca Vitulina*) the grinders are placed obliquely and contiguously, the inner hinder margin of one being in contact with the outer fore margin of the one immediately behind; the first fore-toe the longest. In the Greenland or Harp seal (*Phoca Groenlandica*) the grinders are in a direct line, and separated from each other by well-marked intervals, and second fore-toe is the longest. Our specimen therefore is the Greenland Seal. The colour of this species is said to vary with its age...&c. The one in our possession is a young male, probably in the imperfect clothing of the third or fourth year. An examination of the contents of the stomach proved that this wanderer had fared badly in the bay: for we found nothing but a moderately-sized pulpy mass mixed with the bones of small fish."

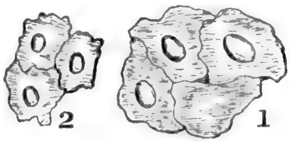
Owing to the doubt thrown by the editors of the "British Quadrupeds" on the *Phoca Groenlandica* as a British species, and their inability to point out undoubted native specimens in our museums, Mr Gough was desirous of obtaining my opinion on the specimen in the Kendal Museum, so that if, after examination, I could confirm his view as to the species, a more formal record of the specimen should be made than a paragraph in the columns of a country newspaper, or an entry in the catalogue of a local museum. The animal had been carefully skinned, and in stuffing and mounting it for preservation in the Museum the mouth had been opened so that the teeth could be examined. I compared its dentition with that, not only of crania of the Greenland seal in the museum of the Edinburgh University, but with skulls of all the northern species of seal, and found its dental characters to correspond exactly with those of the Greenland seal. The unworn condition of the cuspidate molars satisfactorily proved it to be a young specimen. But confirmatory evidence was also furnished by the colour and markings on the fur. It has frequently been pointed out that the young harp seal has a white or greyish white coat with brown spots scattered over it. The colour of this specimen when fresh is referred to by Mr Gough in his description, but in the dried skin I observed that the brown patches of hair were scattered across the shoulders, and down the sides at the roots of the pectoral limbs. Similar patches were seen on the belly and undersurface of the neck. The largest patch 3 in. by $1\frac{3}{4}$ in. was situated on the right side. The markings were not unlike those of the specimen figured by Mr Berjeau in the upper right corner of the plate illustrating Dr Murie's paper on *Phoca Groenlandica* in *Proc. Zool. Soc.* of London, June 23, 1870.

NOTES ON THE MINUTE STRUCTURE OF THE RETINA AND VITREOUS HUMOUR.—By J. C. EWART, M.B., C.M., *Demonstrator of Anatomy in the University of Edinburgh.*

SINCE my paper in the last number of this *Journal*, describing a layer of epithelial cells on the anterior surface of the retina, I have made a further series of observations and have a few additional facts to add. In regard to the retina I have stated that by means of a weak solution of nitrate of silver a layer of epithelial cells may be demonstrated on its anterior surface, and I now wish to shew that a similar layer of cells exists on the surface of the hyaloid membrane of the vitreous humour. Since writing the last paper I have become aware that on the continent certain structures have been described and figured as the anterior surface of the connective-tissue system of "radial-fasern." Although I may have described the irregular outlines of some of these structures as cells, yet I have seen in addition patches of epithelial cells as represented in Figure 1 lying on the anterior surface of the retina.

I have examined the retinæ of the ox, sheep, rabbit, kitten and frog. Of these I find that the cells are most distinctly seen in the sheep. They are best demonstrated by using a $\frac{1}{8}$th per cent. solution of nitrate of silver and then exposing the retina to a bright light. The cells thus obtained are flat, of various sizes, and sometimes distinctly nucleated. They differ from the connective tissue forming the "radial-fasern" and from the ganglion cells seen at a deeper focus. The latter are large branched cells of considerable thickness with a large nucleus and nucleolus, and are generally at some distance from each other. The connective tissue forming the anterior surface of the "radial-fasern" has the appearance of an irregular network, the spaces of which diminish in size on changing the focus. This is best understood by examining vertical sections. When in these spaces small nerve-cells exist, there is sometimes a difficulty in distinguishing the appearance produced from a layer of cells; the fibres however forming the network have generally a double contour, and are thicker than the fine lines produced by the action of silver on intercellular substance.

External granular layer of retina.—Schwalbe in the work of Von Graefe and Saemisch[1] describes in the pike a layer of large irregular nucleated flat cells in the substance of the external granular layer of the retina. In a similar position I have seen in the retina of a kitten a layer of cells having a decided resemblance to those described by Schwalbe. At some parts of the same preparation, by changing the focus, another layer of similar cells was brought into view; thus there may be

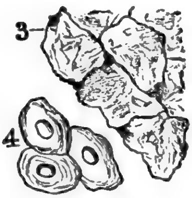


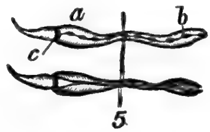
a layer of cells on each surface of the external granular layer, or a double layer in its substance. Some of these cells are reproduced in Figure 2, and though much smaller than those from the pike, they have the same irregular outline, and contrast strongly with the nerve-cells lying superficially to them.

Epithelial investment of the vitreous humour.—Schwalbe describes the vitreous humour as having a distinct hyaloid membrane, but denies the existence of an epithelial layer of cells on its surface as described by Huschke, Ritter and others. The results of observations made by me during the past summer confirm the statements of the latter writers. On the surface of the vitreous humour of a rabbit treated with a weak solution of nitrate of silver and exposed to a bright light in glycerine and water I found the appearances reproduced in Figure 3. These fine lines were traceable over a considerable part of the preparation; and although no nuclei were visible, I consider them conclusive as to the existence of a layer of epithelial cells on the surface of the hyaloid membrane of the vitreous humour. In the same preparation another layer of cells with distinct nuclei was seen at a deeper focus. Some of these cells are reproduced

[1] *Handbuch der Ophthalmologie.*

in Figure 4. They are similar to the flat cells figured by Dr Thin as covering the secondary and tertiary bundles of





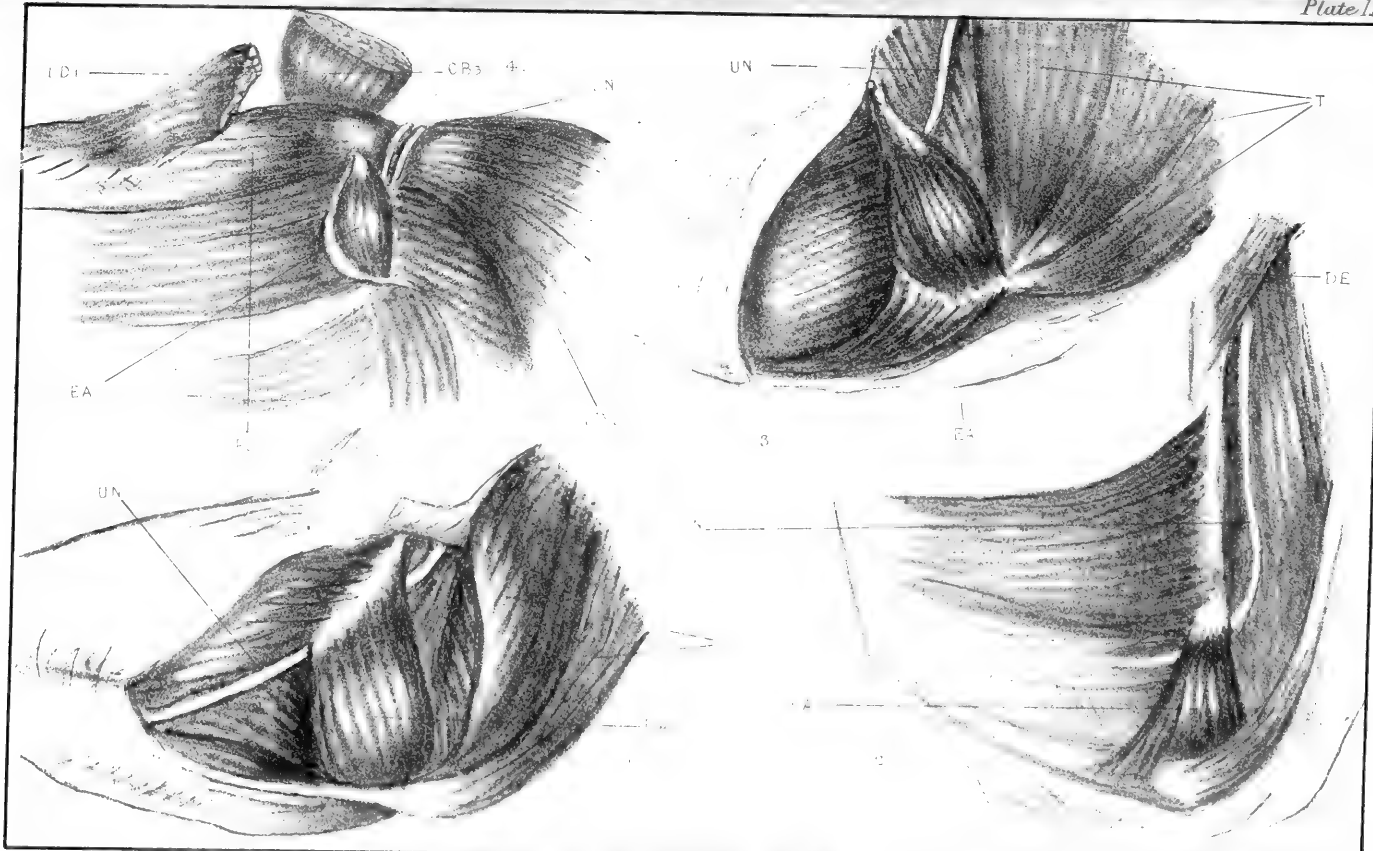
tendon[1], and I regard them as corresponding to the subhyaloid nuclei figured by Schwalbe in the work already referred to. It happened that the cornea of the rabbit, whose vitreous humour I had been examining, had been previously inflamed by a thread which had been inserted and left in the substance of the cornea for some days. But I do not believe the inflammation set up in the cornea had any effect on the cells which I have described as covering the vitreous humour. It may however have led to dilatation of the lymphatic spaces, and thus made way for the easy entrance of the solution of silver between the vitreous humour and the retina[2].

Ending of nerve fibrillæ in the cones of the retina.—Schwalbe also states that nerve-fibres have never been traced beyond the external granular layer of the retina. But in some of my observations on the retina of the common fowl stained with haematoxylin I have found fine nerve-fibrillæ extending beyond the external granular layer as far as the rods and cones. Figure 5 shews what I believe to be a fine-beaded nerve-fibrilla (*b*) passing through the inner segment of a cone (*a*), and ending at the lenticular body (*c*) situated at the junction of the inner and outer segments of the cone.

[1] *Edinburgh Medical Journal*, September, 1874.

[2] It is right that I should state that the investigation into the structure of the vitreous humour was carried on under the directions of Dr Thin. J. C. E.

Plate II.



J. G. Galton, del. et lith.

EPITROCHLEO-ANCONEUS MUSCLE

University Press Cambridge

NOTE ON THE EPITROCHLEO-ANCONEUS OR ANCONEUS SEXTUS (GRUBER). By JOHN C. GALTON, M.A. (OXON.), F.L.S. (Pl. II.)

As the subject of the Epitrochleo-anconeus muscle has been well-nigh exhausted by Professor Wenzel Gruber, of St Petersburg, in an elaborate monograph[1], and an appended supplement[2], it is not my intention to do more than add a few figures of its occurrence in certain mammals whose myology in this respect is not represented in Prof. Gruber's plates, and to make a few general remarks upon the muscle in question; and I am the more encouraged to perform that which to some, nay even to myself, may seem a work of supererogation, by some recent expressions of Dr Burt Wilder, a well-known American anatomist, to the effect that "there is need of more accuracy in the dissection, delineation, and description of muscles, since at present there is great confusion respecting the nature of true muscular integers, and the basis of muscular homologies[3]."

Prof. Gruber, in the first of his monographs on the epitrochleo-anconeus, illustrates the subject by two lithographic plates, the first of which, in five figures, represents its occurrence in man, while in the second plate a comparative view is given of its presence in *Inuus nemestrinus, Cebus fatuellus, Galeopithecus volans, Myogale moschata, Ursus arctos, Felis leo, Felis domestica*[4], *Dasyurus viverrinus, Lepus timidus, Dasypus tricinctus,* and *Phoca vitulina.* This anatomist, though he figures its occurrence in only eleven genera of mammals, exclusive of man, has, nevertheless, found this muscle in no fewer than forty-seven

[1] Ueber den Musculus epitrochleo-anconeus des Menschen und der Säugethiere (mit 3 Tafeln). *Mém. de l'Acad. Imp. des Sciences de St. Pétersbourg*, 7th ser. Tom. x. No. 5.

[2] Nachtrag zur Kenntniss des Musculus epitrochleo-anconeus der Säugethiere. *Bulletins de l'Acad. Imp. des Sciences de St. Pétersb.* Tom. XII. p. 329. No figures accompany this paper. A few supplementary remarks upon this muscle are further made in the course of a paper entitled Ueber den Musculus Anconeus v. des Menschen. *Mémoires.* Tom. XVI. No. 1. 1871.

[3] The Pectoral Muscles of Mammalia. *Proc. Americ. Assoc. for Advancement of Science*, Aug. 1873, p. 307. Published 1874. Ithaca, N. Y.

[4] Possibly the *anconé interne* of Strauss-Durckheim. *Anatomie Descriptive et Comparative du Chat*, Tom. II. p. 351, and Atlas, Plate IX. Fig. 3, 17. Paris, 1845.

genera, a list of which is given at the end of his supplementary paper[5]. I am able to add to this list and give figures of three new genera, viz. *Phascolomys* (*wombata*), *Echidna* (*setosa*), and *Cholopus* (*didactylus*), and to give in addition a figure of the muscle in *Myrmecophaga tamandua,* in which animal it has been already described, but not figured, by Rapp in his well-known monograph[6], under the name of "anconeus parvus."

Georges Cuvier, it is true, has in his magnificent atlas figured this muscle in no less than sixteen genera of mammals[7], but, not only entirely omitting to delineate it, as Prof. Gruber feelingly remarks, in genera where it is undoubtedly present[8], he, when he does represent it, masks it under a crowd of *aliases,* and at times so misrepresents it that we need scarcely wonder at the utterance of one of his own countrymen: "Mais les desseins qu'il en donne sont assez imparfaits, et n'ont pu nous être que d'un faible secours[9]."

The specimens from which my dissections were made were kindly placed at my disposal a few years ago by Professor Rolleston, of Oxford, in order that I might verify certain points in complete dissections which I was making of two members of the Edentata. Unfortunately I have no very full and precise notes of these supplementary dissections, but it will be, I think, practically enough to state that in every instance the epitrochleo-anconeus arched over the ulnar nerve, and that all the drawings are taken from the inner aspect of the right cubital region. I have also in my possession a drawing of the cubital region of the opposite side in a seal (*Phoca vitulina*) which well shews the branchlet given off from the ulnar nerve to the epitrochleo-anconeus, but as Prof. Gruber has figured the self-same region in the same animal in his monograph, I do not consider it worth while to reproduce it here.

The muscle in question seems to be more constant in the Edentata—a group to which, through circumstances, I have

[5] *Nachtrag, &c.* s. 334.

[6] *Anatomische Untersuchungen über die Edentaten.* 2te Auf. s. 48. Tübingen, 1852.

[7] *Anatomie Comparée, recueil des planches de Myologie dessinées par Georges Cuvier, ou exécutées sous ses yeux par M. Laurillard.* Fol. Paris, 1855.

[8] *Nachtrag.* s. 330.

[9] M. Georges Pouchet, *Mémoires sur le Grand Fourmilier.* 1iere Livraison. Paris, 1867.

paid particular attention—than in any other mammalian order, though this may, of course, be due to the fact, that its several members are much fewer in number than those of a larger group, *e.g.* the Carnivora. It has been previously figured and described by Gruber and Murie[10] in *Dasypus* (*Tolypeutes*) *tricinctus,* described and figured by myself[11], and figured only by Cuvier in *Dasypus sexcinctus,* described and figured by Pouchet in the Great Anteater[12], under the name of *vaste interne:* described and figured by myself[13] and described only by Prof. Humphry[14] in *Orycteropus*, and described only by Gruber[15] and Prof. Humphry[16], in *Manis:* by myself as occurring in a very young specimen of *Tatusia novem cinctus* (*D. Peba*), having the umbilical cord still adherent; by Prof. Humphry[17], Gruber, and myself[18] in *Cyclothurus;* by Prof. Humphry and Prof. Macalister[19] in the *Aï*, and by Rapp[20] and Gruber in the *Tamandua;* and, though it is neither figured nor categorically mentioned by Prof. Hyrtl in his truly classical monograph on *Chlamydophorus truncatus*, its presence seems to be hinted at in the following sentence: "Ceterum triceps non omnis metam suam in olecrano attingit, sed crasso lacerto, ultra cubitum producto, internam antebrachii regionem visitat, ubi *Tensoris fasciæ antebrachii* munere fungitur[21]."

From the foregoing then it may be stated that the epitrochleo-anconeus is, almost without exception, present, and well developed, moreover, throughout the whole group of Edentata; but this, of course, may be owing to the fact that from the limited number of the members of this group, the

[10] On the Habits, Structure, and Relations of the Three-banded Armadillo (*Tolypeutes Conurus*). *Trans. Linn. Soc.* Vol. XXX. Tab. 25, Fig. 32.

[11] *Ibid.* Vol. XXVI. p. 539, and Tab. 44, Fig. 2.

[12] *Loc. cit.* p. 11, and Pl. III. *h''*.

[13] *Trans. Linn. Soc.* Vol. XXVI. p. 579, and Tab. 45, Fig. 1.

[14] Under the name of *anconeus internus*. *Journ. of Anat. and Phys.* 2nd Series, Vol. I. p. 301.

[15] In a very young specimen, only 9½ in. long including tail. First Memoir, p. 22.

[16] *Journ. of Anat. and Phys.* Vol. IV. p. 39.

[17] *Ibid.* Meckel makes no mention of the muscle in his description of the anatomy of the Two-toed Anteater. *Meckel's Archiv.* Ver. Bd. 1819.

[18] *Ann. and Mag. Nat. Hist.* 4th Series, Vol. IV. p. 251.

[19] On the Myology of *Bradypus tridactylus*, with remarks on the general anatomy of the Edentata. *Ann. and Mag. Nat. Hist.* 4th Series, Vol. IV. p. 59. 1869.

[20] *Op. cit.* s. 48.

[21] *Denkschrift. der k. Akad. der Wissen. in Wien,* p. 37. IX. Bd. 1855.

means of coming to a correct conclusion have been easier arrived at than had more items been included in the sum total.

Now in the Cheiroptera, on the other hand, to judge from the little which has been contributed to the myology of this order, this muscle is entirely absent, for neither does Prof. Humphry mention its presence in *Pteropus*[22], nor does Prof. Macalister indicate either by figure or description its occurrence in those members of the Cheiroptera, upon the dissection of which his valuable monograph is based[23]. Prof. Gruber, it is true, describes it as present in one of the Cheiroptera, but this is no real exception, as the animal in question, being a *Galeopithecus*, must, in accordance with the most recent system of classification, be placed amongst the Insectivora.

In that smallest of all the mammalian orders, the Monotremata, the epitrochleo-anconeus has been found by Prof. Wood in the *Ornithorhynchus*[24], and by Mr Mivart[25] and myself in two separate species (or varieties?) of *Echidna*, so that we may almost safely assume that this muscle is always present in this order.

In the Ungulata this muscle seems to occur but rarely, or, what is more likely, has not as yet been carefully looked for. The late Prof. Gratiolet, though he does not figure it, seems to have recognised it as a factor of the triceps, for when writing of this muscle in his posthumous work on the Hippopotamus, he says: "Le vaste interne s'attache d'une part à l'une des faces latérales de l'olecrâne et d'autre part à l'humérus. Ses relations avec ce dernier os sont toutes particulières. Il ne s'attache point à sa face postérieure, mais s'enroule sur sa face interne, pour se terminer sur sa face antérieure, jusqu'à la crête qui sépare cette face de la face externe. Cette disposition à l'enroulement

[22] *Journ. of Anat. and Phys.* Vol. III.

[23] *Phil. Trans.* 1872.

[24] *Proc. Roy. Soc.* June 18, 1868, p. 497. In Meckel's description of the muscles of this animal—which is, however, very short—in his well-known monograph there is no mention made of the epitrochleo-anconeus, nor is it figured in any of the plates.

[25] On the Anatomy of Echidna Hystrix. *Trans. Linn. Soc.* Vol. XXV. This anatomist, though he does not specifically mention or figure this muscle, describes, nevertheless, a "distinct slip" of the triceps which "forms an arch (extending from the inner condyle to the olecranon) beneath which pass the inferior profunda artery and the ulnar and median nerve."

est fort analogue à celle que présente le muscle supinateur, et il résulte des conséquences pareilles. En effet, en rapprochant fortement l'olecrâne de l'épitrochlée, le vaste interne est lui-même supinateur à un degré très-prononcé. Rien n'est certainement plus curieuse et plus digne de l'attention du naturaliste philosophe[26]."

With regard to the Carnivora, Rodentia, and Insectivora, the members of these three orders are so numerous that as yet we have not been able to arrive at any generalization as to the occurrence of the epitrochleo-anconeus in them; though there seems to be warrant for the statement that this muscle is fairly frequent in all the three groups.

When we arrive at the Primates we find an evident falling off in the frequency of occurrence of the muscle; for though it is sparingly—certainly not universally[27]—present among the Lemurs and lower monkeys, it seems to become lost among the anthropoid apes[28], and occurs finally in man, though comparatively frequently as a muscular anomaly, still only as an anomaly.

Prof. Gruber, in the first of his two papers (s. 24), rightly concludes that the muscle in question is homologous in man and the other mammals, this conclusion being supported by its nervous supply. In man, however, it is sometimes an independent muscle, sometimes a factor of the triceps brachii, while in the rest of the mammalia it is always an independent structure. It is further stated that its *function* in man is to guard the ulnar nerve and the vessels which accompany it from pressure, and to act as adjutant to the triceps brachii, and to the *ligamentum cubiti mediale* in the way of support of the elbow-joint on its median aspect. In other mammals it acts as an adductor of the olecranon and a supinator of the forearm, being adjutant to the extensor or extensors of the forearm, and serv-

[26] *Recherches sur l'Anatomie de l'Hippopotame, publiées par les soins du Dr. E. Alix*, p. 266, footnote. Paris, 1867.

[27] It is neither mentioned nor figured in Mivart and Murie's most elaborate paper, On the Anatomy of the Lemuroidia. *Trans. Zool. Soc.* Vol. VII. Nor in Burmeister's *Beiträge zur naheren Kenntniss der Gattung Tarsius.* Berlin, 1846.

[28] No mention is made of its presence by Vrolik, Church, or Champneys in their writings on the anatomy of the Chimpanzee, Orang-utan, and *Cynocephalus Anubis*, and Prof. Macalister expressly states, in his paper On the Muscular Anatomy of the Gorilla (*Proc. Roy. Irish Acad.* Vol. I. Ser. II. *Science*, p. 502) "There is no anconeus internus."

ing to protect from pressure either the ulnar nerve and its accompanying vasa alone, or the median nerve and brachial vessels in addition to these.

In man it has the character of a structure retained from an earlier and lower condition of existence, being, in other words, a "Thierbildung," while in other mammals it is a necessary and functional mechanical appendage of the elbow-joint.

In order to find out the frequency of the occurrence of this muscle in man, Prof. Gruber in the space of less than a month examined one hundred bodies, that is, two hundred elbow-regions, and found its frequency thus distributed:—It was met with in 26 males and 8 females, and occurred on both sides in 15 male and 4 female subjects. It was found on one side only in 11 males and 4 females, being on the right side only in 9 males and 3 females, and on the left side alone in 2 males and 1 female. Without reckoning difference of sex it was present in every three subjects and in every four extremities.

This muscle, when present, is generally well developed, rather than weak, in man, and is usually stronger in males, and on the right side, than in females, and on the left side[29].

Up to this time Prof. Gruber had thought that the presence of a third head to the biceps brachialis was the most frequent anomaly in the upper extremity, but he now came to the conclusion that it was exceeded in frequency by the epitrochleo-anconeus.

Though I will readily concede that the epitrochleo-anconeus may in man be occasionally adjutant to the triceps, it seems to be rather a straining after a τέλος to assume that any function other than an active one should be accredited to a muscle rather than it should be simply deemed rudimentary. For I cannot help regarding the function of an organ but as dependent upon its physical capacity, and could as soon conceive of a ligament taking upon itself the active duties of a muscle, as of the latter

[29] Prof. J. Wood found this muscle (see *Proc. Roy. Soc.* June 18, 1858, p. 497) in four male subjects out of 36, in three instances in both arms, and in one on the left side only. A percentage of occurrences of this muscle founded upon Prof. Wood's more limited—thanks to the encouragement to the study of anatomy afforded by the legislature in this country—series of observations is, it will be readily seen, much smaller than one grounded upon the records of the Russian anatomist. This seeming fallacy can, it may possibly be objected, be due not to arithmetical considerations but to real differences of race.

enacting the passive *rôle* of its far less highly organized coadjutor. Better declare at once that a purely muscular slip is functionless, than assume that it exercises the office of protecting a nerve from external injury.

Seeing then that this muscle has been found so frequently in all the lower mammals, and that it is so invariably present in an order—and that, too, one of the lowest—the myology of which, at any rate, has been most carefully studied, while it becomes less frequent among the lower Primates, to finally disappear among the anthropoid apes, and only to emerge again occasionally in man as an "anomaly," we have reason for regarding it, as we do such a structure as the supracondyloid process, as a now almost functionally useless heirloom, which has descended to us from very remote ancestors[30].

[30] One source of difficulty and of probable fallacy must have occurred to every one, though no allusion is made to it in anatomical writings—in the fact that while perhaps only one member of a species among the lower mammals has been once dissected, hundreds of human subjects—in spite of the indifference manifested in the majority of London dissecting rooms—have been under careful investigation, so that it is possible that in the case of the former, instead of that which is normal presenting itself, an anomaly has been stumbled upon, which has forthwith been registered as normal.

EXPLANATION OF PLATE.

Inner aspect of the right elbow-regions in

Fig. 1. *Myrmecophaga Tamandua.*
Fig. 2. *Cholopus Didactylus.*
Fig. 3. *Phascolomys wombata.*
Fig. 4. *Echidna Setosa.*

T.	Triceps.
E. A.	Epitrochleo anconeus.
U. N.	Ulnar nerve.
CB_3.	Coracobrachialis tertius.
LD_1. LD_2.	Latissimus Dorsi, primus et secundus.
F. C. U.	Flexor Carpi Ulnaris.
D. E.	Dorso-epitrochlien.

NOTES ON THE URINE PIGMENTS. By JAMES REOCH, M.A., M.B., *Lecturer on Practical Physiology, College of Medicine, Newcastle-on-Tyne.*

THE following scattered observations may throw some light on one of the most difficult subjects in Chemistry. To get what I shall call the pigmentary strength of urine I mix ½ cc. with 19½ cc. H_2O and allow the mixture to flow into a test-tube placed on a sheet of white paper and compared with a similar test-tube containing distilled water. The moment a distinct colour is perceived, the quantity used is read off and called the pigmentary strength. This method is much more exact than Vogel's where the undiluted urine is compared with mixtures of gamboge and other pigments, and, moreover, it enables the same urine to be compared with itself at different times. Now I have found by this method that the precipitation of uric acid and urates always causes a marked diminution in the pigmentary strength; the latter, more especially when high coloured, will often reduce the pigment to one-half; of course when the precipitated urates are dissolved in hot water the missing pigment is accounted for. There are those who believe in an acid urinary fermentation, which they ascribe to changes in the pigment, but I have never found any change in the pigment, except a greater or less diminution, always accounted for by its attachment to the uric acid and urates. This pigment is red, and gives to uric acid that colour which has secured for it the name of "red sand" deposit; it also renders the urates red, though scarcely so much so, yet the colour seems rather to be due to a salt than an acid, for I find that the invariable effect of alkalies is to increase the pigmentary strength of the urine. Ammonia and potash do this, but chiefly soda, which increases it two or three times. To observe this properly 2 cc. urine are mixed with 2 cc. soda, boiled and filtered from the earthy phosphates: on diluting with the wash-water and comparing it with the original urine, it is found that the pigment is much increased, but more especially the red pigment to which I refer; for the urine, while generally amber yellow, has always more or less of a red tinge. The action of the alkaline earths is quite different from that of the alkalies, for while baryta water does not diminish the pigmentary strength but rather increases it, yet it deprives the urine entirely of the red tinge, and leaves it purely yellow. A further fact in this connection is the action of an acid solution of molybdate of ammonium. In a recent paper on Alloxantin, in the *Chemical News*, I have referred to this subject, and shall here only add, that if a series of test-tubes be taken with 2 cc. urine, 2—100 drops of HNO_3 and HCl, and 2 drops of a saturated solution of molybdate of ammonium be added to each, the next day the colour will be found green in the lower HNO_3 series, and green with a tinge of blue in the lower HCl, while the higher of each exhibit no change. Now this something, whatever it is, which reduces the molybdate, is attached to the red pigment, for by washing the urates and dissolving them in hot water they are seen to act nearly as powerfully as the urine itself, though pure uric acid has no effect whatever. Moreover, it is precipitated by baryta water, for the yellow filtrate from the latter no longer reduces the molybdate; but if the precipitate be treated with dilute HCl it will do so, and if evaporated, crystals, similar to alloxantin, may be got amongst many others of hippuric acid and salts. The blue colour is not stronger than what may be obtained from 3 grs. of alloxantin per diem; but even though this body be admitted as one of the pigmentary constituents of urine it would not explain the red pigment, for it does not form any coloured salt with soda, yet it points to the direction in which an explanation must be sought for. Alloxantin is one of the intermediate products between uric acid and urea, and is intimately connected with murexide, one of the most powerful of known pigments. Further facts in the same direction are that urates invariably become much more pink when exposed to the air, which is a characteristic of the bodies from which murexide is obtained. Moreover, when HNO_3 is added to 2 cc. of urine of sp. gr. of 1028, I have always found after 24 hours, that when 2—10 drops were added the colour was progressively darker red, and some uric acid had precipitated, but above this the redness diminished and also the uric acid until with 16 or 20 drops up to 50 or 60 the colour was pure yellow, and nitrate of urea had precipitated instead of uric acid. This fact, which I have found constant in a urine of considerable specific gravity, seems to point to a much closer relation between the urea and uric acid than many suppose.

The pigment which gives the urine its yellow colour is not nearly so well defined in its character as the red pigment connected with the uric acid. It has been supposed by Schunck and others to be of the Indigo family, and there is no doubt that a blue pigment may often be obtained from it; but our knowledge is imperfect in regard to the mode of its production. After the red pigment of the urine is precipitated by baryta the yellow solution may be decolorized by nitrate of mercury, but the uréa is also thrown down, so that an analysis is contra-indicated. Corrosive sublimate precipitates a considerable amount of this colouring matter of the urine along with the urates, for the precipitate is rendered pink by HCl, and yields uric acid as well. About two-thirds of the pigment is in this way thrown down, but an even larger quantity is precipitated by acetate of lead. The most remarkable characteristic of the second urine pigment is its being turned pink or brownish red by HCl and H_2SO_4. The red pigment is not affected in this way, for the "red sand" deposit is simply decolorized when boiled with HCl, but the yellow, left after the red pigment is thrown down by baryta, shews the violet colour extremely well when treated with strong HCl. The action of acids, and indeed of most reagents on the urine, is best studied by a comparison of the effect of successive amounts added to 2 cc. Thus, if 2—100 drops of strong HCl or H_2SO_4 be added to a series of test-tubes containing 2 cc. urine each, it will be found that H_2SO_4 will darken the colour more quickly, probably from the greater heat developed; but with HCl there is only a slight alteration, unless the fluid be boiled, though, if allowed to stand for 24 hours, it will come out equally well: it is independent of any oxidation from the air, for it comes out when the air is excluded, but seems to require time for its development simply from the small quantity contained in the urine. The darkening increases up to 8 or 10 cc. of strong acid, but beyond that further acid acts like water, and simply dilutes the colour. The action of acids on this pigment seems to point to its albuminoid nature, for it is well known that albumen when boiled with strong HNO_3 yields a deep yellow solution, but with HCl or H_2SO_4 a deep violet or pinkish red solution is the result: this is exactly the effect of these strong acids on the urine, and they therefore would seem to indicate the derivation of this pigment from an albuminous source.

I have thus far spoken of two pigments which give to the urine its yellow colour with tinge of red, and it will be evident, from what I have mentioned, that two very different causes may give rise to that condition known as "high-coloured" urine, for it seems to me a grave mistake to impute, as many do, all cases of high-coloured urine to increased concentration. The latter must always be accompanied with a corresponding increase in the specific gravity, so that to double the pigment would double the latter also; but the pigment is often much more than doubled, while the alteration in specific gravity is comparatively trifling. Independently of concentration there may be increase of the red pigment, indicated by increase of the urates to which it is principally attached, and there may also be no increase of the red pigment, but a metamorphosis of the other pigment by increased secretion of acid within the system causing it to be darkened. The precipitation of uric acid in the latter case would be caused by the increased acidity of the urine, but might of course depend to some extent on the fact, that the same cause which increases the acidity of the system might also increase the uric acid.

NOTES OF ABNORMALITIES IN THE ARTERIES OF THE UPPER EXTREMITY. By J. J. Charles, M.A., M.D., *Demonstrator of Anatomy, Queen's College, Belfast.*

In a female subject, 70 years of age, dissected last winter in the Belfast Anatomical Rooms, the arteries of the upper extremities presented a greater number of abnormalities than we generally meet with in one and the same body.

Right upper extremity. In this extremity the posterior circumflex and dorsalis scapulæ arose together a little above the origin of the anterior circumflex, and one inch and a half below the subscapular; the latter was comparatively small, and soon divided into a number of branches for the subscapularis and teres major. The superior and inferior profundæ came off together from the axillary, half an inch above the lower border of the teres major. The branch for the biceps was large, took origin from the commencement of the brachial, and supplied offsets to the inner border and deep surface of that muscle in the middle of the arm. From this muscular branch, one inch and a half below its origin, sprung a slender branch—a vas aberrans—which ran downwards on the outer side of the brachial along the inner border of the biceps as far as the elbow; it then crossed to the outside over the tendon of the biceps, and lay partly concealed by the supinator longus till it reached the middle of the radius, where it joined the radial at an acute angle. The vas aberrans was ten inches long, and was filled with injection except for two inches and a half in the middle of its extent. It was comparatively superficial throughout its whole course, and rested successively on the brachialis anticus, the tendon of the biceps, recurrent radial, supinator brevis, and pronator radii teres. The brachial divided one inch below the neck of the radius into two branches of nearly equal size: the ulnar and a trunk about a quarter of an inch in length. This trunk terminated in three branches, the radial, and the anterior and posterior interosseous, the two latter being of almost the same size, but smaller than the radial. The ulnar took a normal course to the palm of the hand, but supplied only two digits and a half, there being no "superficial arch." The anterior and posterior ulnar recurrents were derived from the front of the brachial just above its termination, and had a normal distribution. The radial became appreciably larger below the point of union with the vas aberrans, and gave off the usual branches to the wrist and hand. The median artery arose from the radial an inch and a half below its origin, and accompanied the median nerve to the palm of the hand, where it terminated by dividing into two branches for the contiguous sides of the index and middle fingers. The radial recurrent was derived from the brachial above the neck of the radius, and was normal in its distribution.

In one of his plates[1] Quain delineates an arrangement of arteries similar in some respects to that I have detailed above; and in the text he mentions two different ways in which that arrangement might be considered and described. The case before us, too, it is possible to consider and describe differently. The radial may be said to have had a double origin, one (the vas aberrans) indirectly from the beginning of the brachial, and the other (a cross branch) from its termination. Indeed, there is some reason for believing that the inferior root came from the interosseous, as it gives off the median artery; and the disposition of the arteries in the left extremity supports this view. According to the first hypothesis, the median took its rise from the radial, an abnormality of very rare occurrence, since Quain does not record a like instance.

Left upper extremity. In this extremity the subscapular was small, and the superior and inferior profundæ took origin by a common trunk. The radial arose from the inner side of the commencement of the brachial, and curved downwards parallel with that vessel until it reached the elbow, where it crossed the main trunk to the outer side, whence it maintained its ordinary course. As is usual in such cases, the radial recurrent sprung from the brachial (ulnar-interosseous). The interosseous artery and its branches were normal in their origin and distribution, with the exception of the median, which arose directly from the interosseous trunk. The median artery was smaller than on the right side, and ended by supplying offsets to the flexor sublimis digitorum. The ulnar was quite normal in its course and branches.

The disposition of the arteries in these extremities is interesting as illustrative of the manner in which it is believed a high origin of one of the vessels of the forearm is produced[2]. On the right side we find a more rudimentary stage than on the left. The vas aberrans in the right, and the radial in the left, closely correspond in their origin and course; but the upper part of the radial, according to the first view stated above, has diminished in size, though it has not become obliterated and absorbed as its counterpart on the left.

It will be observed that in this body the arteries of the upper extremities shewed very little correspondence in their arrangement. The abnormalities just pointed out, taken in conjunction with those I described in a previous number of this *Journal*[3], furnish evidence in support of the view of Bichat and Quain that lateral symmetry is not maintained in malformations.

[1] No. 35; Fig. 4.
[2] Quain and Sharpey's *Anatomy*, last edition, p. 392.
[3] June, 1873.

DISSECTION OF AN ABNORMAL FOUR-TOED FŒTUS WITHOUT HEAD OR UPPER LIMBS. By JOHN HARKER, M.R.C.S., *Lancaster*.

I AM induced to publish the dissection of an imperfectly developed fœtus on account of the interest involved in the relation which its nervous system, so far as it was developed, bore to the condition of the viscera.

On May the third I attended Mrs C. at her ninth birth, she was confined prematurely, at the fifth month, of male twins. The first was born at 2.30, normal but dead, and discoloured brown. Hæmorrhage ensued, on account of which, I ruptured the second set of membranes and with my fore and index fingers reached down the foot of the second twin, which was slender, with only four toes—a great toe and three others, and the hæmorrhage now abated. The uterine pains were but slight, yet in half an hour a malformed fœtus was expelled.

The legs with the exception of the four-toed feet were well developed, as also the pelvis. There was an anus and male genital organs, but from the pelvis upwards the body consisted of a mere round mass with no upper extremities, no head or features, no orifices, no neck; on the front of this body two shallow indentations led to the part where the umbilical cord was inserted in a deep cleft, on each side of the upper eminence formed between these indentations two pellucid spots were noticed, perhaps these were conjunctival corneæ; I shall refer again to them, they were mere skin structures. The umbilical cord was short, with little albumen about its vessels, and was very fragile; on the expulsion of a single placenta it was found to have originated from that body, at one side, close to the membranes, whilst the cord of the normal fœtus was implanted in the centre.

Dissection.—First an attempt was made to trace out the vertebral column, then the abdomen was examined, next the thorax, next the viscera in detail, then the spinal cord and nervous system, lastly the lower extremities. Weight of the fœtus, one pound one ounce and three quarters; length eight inches, of this from os calcis of left foot to crest of the left ilium four inches, from the crest to the top of the round mass four inches; diameter of mass three inches and three quarters. The skin was entire and complete over the whole surface of the fœtus, but the epidermis over the mass was beginning to peel off.

A longitudinal incision was made in the direction of the spinal column from the sacrum to the top of the mass through the skin and subcutaneous fat. By this a smooth serous cyst was revealed in capacity about the size of a hen's egg; in the serum which filled it, a few fibres of white nerve-tissue floated. This cranial cyst occupied the interior of the highest part of the mass, it had no connection with the spinal column, its deep wall merely resting over the spines of the dorsal vertebræ. A prolongation of the incision to the cornea-like marks (mentioned above) shewed that there was no connection between them and the serous cavity, neither was there with the cornea the least trace of nerve-tissue or choroid pigment; the marks were mere dermic simulations.

Examination of the spine shewed that the column did not extend upwards further than the first dorsal vertebra, which last, indeed, was reduced to a mere nodule. There was no trace of cervical or cranial vertebræ. The upper dorsal vertebræ were bent somewhat forward, so as to arch over the thorax; to the dorsal vertebræ were attached rudimentary ribs, but there was no sternum, and the upper extremities were entirely deficient.

Abdomen.—The abdominal walls were very thin, particularly in the neighbourhood of the umbilical cord. The cavity was found to contain an intestine, which beginning with a perfectly closed pouch, had a small stomach portion, bent at an oblique angle to the small intestine. The small intestine was normal in its direction and opened into the large intestine in the usual manner. To the large intestine there was appended a considerable appendix vermiformis; the rectum terminated at the anus in a normal manner. The entire gut was quite empty, and there was not the least trace of liver-duct or hepatic tissue in connection with it; in fact the liver was entirely absent from the abdomen. There was no trace of a spleen with the stomach portion of the intestine, and the mesentery was very clean. There were no supra-renal capsules. A small rudimentary kidney existed on the left side. The abdominal cavity was separated from the thorax by a diaphragm of remarkable fineness which did not appear to possess muscular tissue. On opening the thorax a normal heart was exposed with lungs. The lungs were developed in a glandular manner, and did not possess tracheæ or bronchi.

Circulation.—The umbilical vein was continued as a ductus venosus through a little dense cellular tissue to join the omphalo-mesenteric vein and so entered the heart. From the heart, besides the pulmonary vessels, emerged an aortic vessel, which formed a simple thoracic arch without giving off innominate, carotid, or subclavian branches. It was distributed to the intestines and by the common iliac arteries to the lower extremities chiefly. On removing the heart and lungs from the chest, no trace of œsophagus could be discovered. The lungs when further examined were found to consist of mere parenchymatous tissue without bronchi or muscular tissue. The vertebral column when cleared from muscular tissue was found to consist only of the dorsal, lumbar, sacral, and coccygeal vertebræ; and of the dorsal vertebræ, the first dorsal was reduced to a mere centrum. On opening the spinal canal, the spinal cord was found to be extremely attenuated above, but increased gradually in thickness, and was normal at about the sixth dorsal vertebra; and so continued, giving off the dorsal, lumbar and sacral nerves, in a normal manner.

Examination of the four-toed feet shewed that the little toe with its metatarsal bone was the deficient ray.

It is evident in this case that the ovum through its chorion failed to obtain a proper amount of nutriment from the maternal uterus and to form a sufficient placenta, and hence in the fœtus only the thoracico-abdominal parts of the body are developed, the upper parts, which in healthy development take a free supply of good blood, being deficient. There is a close relation between the condition of the nervous system and the state of the organs formed; for just as the absence of the neck-vertebræ and the brachial plexus is accompanied by the entire absence of the upper extremities, so the absence of the respiratory tract and its nerves is associated with the absence of the face, pharynx, œsophagus, trachea; and absence of the muscular tissue of the diaphragm is associated with the absent phrenic nerves. The condition of the lungs also is interesting, for normal lungs are formed in the embryo as diverticula from the œsophagus, at first as tracheæ with bronchial extensions, each portion of the tube being accompanied by a plexus of nerves from the pneumogastric nerves. The pneumogastric nerves are here absent, and so are the tracheæ and bronchi, but this interesting case shews a double origin for the lungs, a second one being a vascular extension; for we have here the lungs developed as a mere parenchymatous tissue.

Absence of the liver masses has been noticed by writers. The cranial cyst needs no particular remark.

NOTE ON THE ABSENCE OF THE QUADRATUS FEMORIS MUSCLE AND ON A SPINE POSSESSING A SIXTH LUMBAR VERTEBRA, THE FIRST RIB BEING RUDIMENTARY.—Communicated by EDWARD BELLAMY, F.R.C.S., *Senior Assistant Surgeon and Lecturer on Anatomy at Charing Cross Hospital, and in the National Art Training School, S. Kensington.*

DR JAMES CANTLIE, the Demonstrator of Anatomy at Charing Cross Hospital, called my attention to these peculiarities in the human subject, and which I think worthy of being recorded.

The first is an instance of entire absence on *both* sides of the Quadratus Femoris muscle. The subject was a female. In this instance, as has been elsewhere recorded, the obturator internus and gemelli were greatly developed, and had evidently, as far as the mechanism of the movements of the hip-joint were concerned, supplied its place. Mr J. C. Galton has kindly favoured me with the following note upon this irregularity. He says:

"I have found in the Cape Ant-eater (*Trans. Linn. Soc.* Vol. XXVI. p. 589) that while the Quadratus femoris was absent, the gemelli, on the contrary, were very well developed. Thiele (*Encyclopédie Anatomique*, Vol. III. p. 279, Paris, 1843) notices the occasional absence of this muscle in Man, and further observes that 'alors les jumaux ont plus de volume.' With the only instance in which Hallet (*Edin. Med. and Surg. Jour.* Vol. LXIX. p. 20, 1848) found the *quadratus femoris* deficient in Man (out of 105 subjects examined), there was associated an unusual development of the two *gemelli* and *obturator internus.*

"On reference being made to my paper on *Dasypus sexcinctus* (*loc. cit.* p. 551), it will be seen that while the muscle in question is in this animal exceedingly well developed, the *obturator internus* is absent, and the *gemelli* very small—the converse of Theile's and Hallet's observations being thus illustrated in a very singular manner.

"Dr Murie, in a monograph recently published (*Trans. Linn. Soc.* Vol. XXX.) on the Three-banded Armadillo (*Tolypeutes conurus*) observed (pp. 96, 97) that while there were only 'a pair of feeble gemelli,' 'a longish goodly-sized quadratus femoris' was present."

I do not remember myself to have before met with this condition, although I was aware that it had been noted. In one instance I found the lower edge of the muscle in question incorporated with the fibres of the adductor magnus, but I have no note of the case.

The second is an instance in which the first rib was found on either side to be rudimentary. The whole length of the process, which represented the rib, measured about an inch and a half, and resembled a small horn attached to the first dorsal vertebra. The processes on either side are exactly alike[1]. The surrounding relations were nor-

[1] [See description of similar case p. 44 of this number of the *Journal*.]

mal. The first dorsal nerve with the superior intercostal artery lay on its anterior surface and behind it touched the transverse process. The peculiarities in front where the rib was wanting were; that,

(1) The subclavian artery was in its normal position; it did not appear above the level of the clavicle, but on taking away the clavicle the artery was seen two inches above the level of the highest rib.

This rib on farther dissection proved to be the 2nd, so that the subclavian was in its normal position, although wanting bony support.

(2) The scalene muscles descended in front and behind the vessel, and, after forming a junction below the vessel, passed on to be inserted to the 2nd rib. The *anterior* scalene passed backwards, internal to the other scaleni, to be inserted into the upper border of the 2nd rib, in about the middle of its course. The middle scalene passed forwards, external to the anterior muscle, to be inserted into the upper border and outer surface of the anterior part of the 2nd rib, for about $\frac{1}{3}$rd of its length.

The posterior scalene was normal. These scalene muscles were mistaken at first for intercostal muscles, as their direction and position exactly tallied with the intercostals.

In the same body there were six lumbar vertebræ; and neither of these have any trace of a rib attached to them. The vertebræ are as follows: 7 cervical, 12 dorsal, 6 lumbar.

The deficiency in the dorsal ribs is in this instance made up in some measure by a 6th lumbar vertebra, the first of which certainly bore no osseous trace whatever of a rib. I cannot find any similar case recorded, and am therefore induced to place the foregoing on record.

NOTICES OF BOOKS.

The Elements of Embryology, by M. FOSTER, M.A., M.D., F.R.S., Fellow and Prælector of Physiology in Trinity College, Cambridge, and F. M. BALFOUR, B.A., Fellow of Trinity College, Cambridge. Part I. Macmillan, 1874. Pp. 272, with seventy-one Woodcuts.

IT is remarkable that hitherto there has been no English text-book on Embryology. Indeed, if we except Dr Martin Barry and Prof. Allen Thomson, scarcely any anatomists in this country had contributed to the embryology of vertebrata until Mr Parker's recent researches, and even his admirable work has been rather osteological than embryological in its scope. It is therefore a subject for congratulation that the task should now be undertaken by those who are able to do it well. It must be very gratifying to Dr Foster that, during the short time since he migrated to Cambridge, he has succeeded in founding a flourishing school of physiology, and that he is now able to associate with himself in this important work one of the most distinguished of his pupils. Mr Balfour's admirable researches on the development of Selachii[1] sufficiently prove his capacity for the patient industry and the sound judgment necessary in this difficult branch of science.

If this book were a general sketch of embryology, such as might be acceptable to zoologists and medical men who have no time or no inclination to go thoroughly into the subject, there are several English physiologists who might have written it. Such a semi-popular work would perhaps be useful, though Prof. Hæckel's recent "Anthropogenie" proves how easily a man of genius may fail in such a task. But Dr Foster's plan is, if not more difficult, much more important and laborious. The present volume, containing a full account of the development of the Chick, will be followed by a second on that of Vertebrata generally, with special reference to human embryology, and completed by one dealing with the salient points of development among the Invertebrata. The last will be the most difficult part, from the immense range of the subject and the impossibility of verifying or correcting the statements of other observers in the way which has been done in the first, and no doubt will be in the second volume. But it may perhaps be the most generally interesting, especially if the writers should, as we hope, enter on the hazardous but fascinating problems of the mechanical causes of development, the homology of embryonic parts, and the bearing of the whole subject on classification and phylogeny.

They have, however, with a boldness which does not need success to justify it, begun by the minute and somewhat dry details of the development of a single form which occupy the well-filled pages of this first volume. Anatomy must precede physiology: and though we may regret that no nearer ally of the animal most interesting to ourselves can be found equally fitted for examination, or wish at least that some less aberrant group than Aves had become domestic egg-layers, yet there can be no question that on every ground of historical fitness, of practical convenience, and of previously established knowledge, the development of the chick is the one with which a practical study of embryology must begin. At the end of the book are careful and precise directions for conducting all the examinations necessary. They are much more minute than those given by Dr Klein in the Handbook for the Physiological Laboratory, and, indeed, are such that anyone accustomed to work at normal or pathological histology will be able by following them to see for themselves what hitherto they have only read of.

The only part of the volume which is not strictly practical is the introduction, which gives a short sketch of the progress of embryology from Fabricius ab Aquapendente to the present time. So far however from objecting to this, we wish it had been much longer. Every scientific treatise should be preceded by some account of the

[1] See the *Quarterly Journal of Microscopical Science*, October, 1874.

steps by which the knowledge it imparts has been obtained: this not only gives a human interest to the driest studies, but forms a valuable help in avoiding a prejudiced or private interpretation of facts: and the history of the development of Embryology by the discoveries of Harvey, Wolff, Pander, von Baer, and their successors, is only second in instruction to that of the development of the embryo itself.

In accordance with the analytical rather than systematic character of the book, it begins by describing the structure of a new-laid egg, and only afterwards returns to its previous formation in the ovary.

The second chapter is a brief summary of the changes which take place during incubation, and serves as a kind of table of contents to the well-told history which follows.

This is related in a nearly strict chronological order down to the end of the fifth day of incubation. For practical purposes this plan is obviously the right one, though the interest of the continuous evolution of the several organs is somewhat impaired. However, Dr Foster is too experienced a teacher to be shy of recapitulation, and thus contrives to pick up the threads of organic development from time to time. And there is a special and dramatic interest which attends the successive work of each day, as the reader, and still more the observer, sees repeated before his eyes the marvellous work of creation.

Up to this point the process of development described has been vertebrate or amniotic, or at least sauropsidan: the subsequent more specialized history of the embryo is treated in a somewhat different manner. The object of the authors is to use the chick as the most convenient example of development, but not to describe minutely that of the genus *Phasianus*, or even of birds as a class: and accordingly the changes which occur from the sixth day to the end of incubation are given in a more general manner, and occupy only a single chapter.

The last chapter is devoted to the development of the skull of the fowl, being chiefly based on Mr Parker's elaborate memoir. At first sight this seems an inadequate way of dealing with so important a subject, especially as the skull of birds, while not less aberrant than the rest of their anatomy, offers peculiar difficulties in its development. But here again the object is a practical one, and the ease with which material can be obtained is decisive.

Although the authors so steadily refrain from comparisons with other embryonic structures, from questions of causation, and from "theoretical considerations generally," the book is far from being a mere accurate and well-arranged manual of dissection. Disputed points are discussed with considerable fulness, and minutiæ beyond the reach of a first course in embryology find their due place; but these are all printed in smaller type, so as not to impede the student in a first perusal.

The illustrations are sufficiently numerous, and, though all woodcuts, are mostly clear and efficient. It would perhaps have been better if in some no attempt at a picture had been made, and a mere diagram substituted: and we think that the graphic and homely verbal illustrations which are occasionally introduced might have been more freely used. None but teachers of anatomy know what difficulty some persons find in realizing almost any arrangement of objects in space of three dimensions, and that even when they can be handled. When a student is tolerably familiar with longitudinal and transverse sections of an embryo, it requires some effort of *Vorstellungskraft* to combine them with one another and with the views gained of the blastoderm or fœtus as an opaque object.

We consider the present text-book as an index of the revival of embryology in the country. Beside students of physiology it addresses only a certain proportion of zoologists and other scientific men, and, as we have seen, the authors have refused to write down to a popular standard.

Hitherto the success of this kind of scientific literature has not been encouraging to writers, or creditable to the state of Biology in England. Mr Parker's great work on the shoulder-girdle could not have been published except by the wise help of the Ray Society, and we fear that that association lost in purse almost as much as they gained in reputation by the venture. Professor Huxley's admirable Lectures on the skull were only "floated" by the chapters on classification which were bound up with them. Mr Flower has not followed his excellent text-book on the Osteology of Mammalia by the expected sequel on their teeth and viscera, but we hope that with restored health he will be encouraged to do so. Such an encouragement will be given by a good sale of the present volume, and this we heartily wish, not only because Dr Foster and Mr Balfour will then be enabled to complete the task so well begun, but because it will be a welcome sign that there is an English public for text-books of the best kind on purely scientific subjects.

The Histology and Histochemistry of Man. By HEINRICH FREY, Professor of Medicine in Zurich, translated from the fourth German edition by ARTHUR E. BARKER, Demonstrator of Anatomy, Royal College of Surgeons, Ireland, with 608 Engravings on wood, revised by the author. Churchill, 1874.

We are glad to see Professor Frey's valuable and richly illustrated work rendered thus accessible to English reading students by means of a good translation. It will prove a valuable book to them, being one of the best available sources of information in the important subjects of minute anatomy and associated chemistry.

REPORT ON THE PROGRESS OF ANATOMY[1].

By Prof. TURNER and D. J. CUNNINGHAM, M.B. C.M.

OSSEOUS SYSTEM.—Wenzel Gruber communicates (*Mém. de l'Acad. Imp. de St. Pétersbourg*, XXI. 1874) an elaborate memoir on the variations in position, size and shape of the INFRA-ORBITAL CANAL in MAN AND MAMMALS.——Gruber also publishes in *Reichert u. du Bois Reymond's Archiv*, 1873, p. 337, some remarks on SUPERNUMERARY BONES in the ZYGOMATIC ARCH. On p. 348, observations on the SEMI-INFUNDIBULUM INFRA-MAXILLARE, the SULCUS MYLOHYOIDEUS and the bridge of bone over it. On p. 706 and 712, some additional observations on SUPERNUMERARY BONES in the CARPUS.——G. Wegner makes (*Virchow's Archiv*, July, 1874) a critical enquiry into the normal and pathological GROWTH OF THE TUBULAR BONES.——A. v. Brunn concludes, from his observations on OSSIFICATION (*Reichert u. du Bois Reymond's Archiv*, 1874, I.), that the cartilage-cells persist in the medullary spaces as marrow-cells, from which they become converted into osteoblasts, and as such form bone; that whilst the greatest part form the matrix of bone, a part remains as the bone-corpuscles; the canals in bone are due to absorption.——T. Zaaijer communicates (*Nederland. Tijdschrift voor Geneesk*, 1874) a paper on the CONSTRUCTION AND GROWTH OF THE BONES.——Paul Langerhans contributes (*Virchow's Archiv*, LXI. 229) a paper on the ARCHITECTURE of the SPONGY TISSUE of bones.

CARTILAGE, CONNECTIVE TISSUE AND MUSCLE.—R. Deutschmann communicates a paper (*Reichert u. du Bois Reymond's Archiv*, 1873, 732) on the development of ELASTIC FIBRES in the yellow fibro-cartilages.——Ranvier contributes (*Arch. de Phys.* 1874, 181) new observations ON THE STRUCTURE AND DEVELOPMENT OF TENDONS, and modifies in some points the opinion he first brought forward upon the form of the cells of tendon. The first part of his memoir is devoted to an account of the present state of science upon the subject. He then seeks to shew that the forms of the cells of tendon are not always the same, and with this in view he gives the results of his examination of several types of tendon. In osmic acid preparations of tendon taken from the tail of a young rat and teased, he states that he finds along the tendinous bundles cells either forming a complete series or separated one from the other. Some are seen to float freely in the fluid. These cells are finely granular and nucleated, and in appearance they somewhat resemble a tile or gutter—the concave side being applied to the bundle, whilst the convex surface is in contact with the neighbouring bundles. Further, they shew ridges, or rather jutting-out crests, parallel or oblique to the lateral borders of the cell. These ridges form part of

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

the cell itself. In transverse sections of tendon hardened by picric acid, and then treated with carmine, he describes a very complex system of partitions and red-coloured fibres; and he states that by comparing preparations obtained by the use of picric acid with osmic acid preparations, we are able to recognise the extent of the cells and of the fascicular sheaths. In the former the sheaths form complete circles, and cannot be distinguished from the cells, and they send prolongations into the interior of the bundle, which end in fibres differing essentially from connective tissue and elastic fibres. In the latter we observe stellate cells with short prolongations passing in different directions. In the young rat the cells are elongated and flat, and present in different directions longitudinal, angular juttings-out or ridges; this we see by a study of longitudinal and transverse sections. In the adult rat the cells are extremely thin, and send in various directions fine prolongations, which spread between the bundles.

In tendon placed first in osmic acid and then treated by acetic acid we notice that the cells are limited, the one in relation to the other in the same series, by transverse or oblique lines, and in such a manner that they appear rectangular or trapezoidal. In his first paper he mistook two ridges for the lateral limits. These he now states cannot be determined with certainty.

The nuclei of the cells have no nucleoli, and occupy a peculiar position in the cell. They are placed close to the extremity of the cell, and in such a manner that two neighbouring cells have alternately their nuclei close to or at a distance from each other. In a series of cells, therefore, the nuclei are seen to be grouped in pairs. M. Ranvier then discusses the appearance known as "Boll's elastic stria." He maintains that it is not a stria, but a projecting ridge. It is better marked upon the nuclei than upon the body of the cell; indeed it is sometimes to be seen solely upon the nucleus. When observed upon one cell it is seen to stop at the border of the cell, and to commence again upon the neighbouring cells. He calls it "*crêté d'imprinte.*" When the cells are seen edgeways they resemble small rods slightly swollen at the level of the nucleus. He then describes a peculiar arrangement of cells, in which the cellular plate is divided into two parts by a ridge. Of these parts we see the surface of one, whilst we only obtain a three-fourths view of the other. In fact, the cell is bent so as to resemble a book three-fourths open. The nucleus which is situated at the level of the crest is bent like the rest of the cell. In the aponeurosis of the frog's thigh he considers that he has found a perfect demonstration of the impressions left upon the nuclei by the bundles between which they are placed. When treated by carmine, and then by acetic acid, we observe fine lines of a rose colour crossing each other at a right angle, and enclosing clear squares like those of a chess-board. These fibrous bundles are in two planes—one external, constituting a layer of parallel bundles, the other internal, composed of similar bundles, but crossing the former perpendicularly. The nuclei only of the cells on the surface of the fasciculi are well marked, and these possess most varied and peculiar shapes. They are flat and elliptical, but when seen edgeways they occupy the spaces between the two bundles of the same layer and resemble small rods. Some assume the shape of a Latin or of a Russian cross, of which the arms are at a different level. Others again are like a half-moon, with a well-marked rectilinear border: upon the half-moon are two transverse ridges or crests. These last shapes are due to the varied manner in which the nuclei are applied to the bundles. They bear the impressions made upon them by the neighbouring bundles and by the interstices. He next gives the results of some observations he has made upon the sesamoid cartilage of the tendo-Achillis of the frog. He describes the cells, when a section of this has been treated by a solution of iodine, as being round or irregular transparent bodies, and scarcely tinted yellow by the iodine. They have an ovular nucleus rarely occupying the centre of the cell, and close to this we observe a little star-like granular body of a yellowish-brown colour. They contain no glycogen and no oil-globules. They thus differ very greatly from cartilage-cells, which are deeply tinted by iodine, contain glycogen and oil-globules, and retract upon their contents so as to form a shapeless mass. As to the little granular body, which is rarely absent, and which always bears the same relation to the nucleus, its analogue is difficult to find. That we occasionally find a calcified point in the nodule, even although this approaches in character to ossification, is no proof that the nodule is originally formed from cartilage, for ossification is not produced in cartilage alone.

Ranvier next analyses the structure of the chondroid portion of the tendons in the foot of the chicken, turkey, &c. He states that we find in these parallel bundles and a series of cells differing from those of tendon, inasmuch as they are not flat, but cylindrical or polyhedral. These cells are separated from each other by a transparent homogeneous intercellular substance, which, unlike that of cartilage, is slightly coloured by carmine. On transverse section we see the cells in the shape of circles with the nucleus in the centre, and the tendinous bundles in the form of colourless circles embedded in a red matter. In sections of completely ossified tendon when treated by picric acid and then carmine and acetic acid, we notice the Haversian canals cut across, and around these a zone more deeply tinted than the rest of the preparation, and resembling the lamellar system of long bones. These are not true osseous lamellæ. The osseous substance appears to be formed around the vessels by tendinous bundles, which on transverse section form as many little circles. Thus, although the tissue is truly osseous, it is evident that the fundamental osseous substance is chiefly represented by the transformed tendinous bundles. In a word, the ossified tendons of birds are almost entirely constituted by the fibres of Sharpey. He states that, besides the proofs already given, others may be drawn from the examination of these tendons by polarized light. Beyond the chondroid or ossified parts the tendons present the ordinary structure. The flat cells are very large, and have thread like prolongations, which extend upon the bundles for a considerable distance.

Ranvier has also studied the structure of the tendons of the tail of the mole, and finds that in some respects it resembles the tendons of birds. Between the bundles he found series of cylindrical cells, placed end to end and cemented together so as to form chains of cells, which he was able to isolate by maceration in picric acid. Sometimes these cells present filamentous processes passing from them, and sometimes the chain itself ends in a slender thread, in which we find no trace of cellular elements. Ranvier now draws attention to the fact that, whilst the bundles of tendon are always similar, the cells have their shape influenced by the age of the animal and the type of tendon in which they are found. Originally, in the embryonic state globular, they may assume any of the varied forms he has described. The latter part of his memoir he devotes to an account of the development of tendon. He states that the tendinous bundles originate in a mass of cartilage, and terminate in a primitive muscular fasciculus, and that the increase in length of tendon takes place at the point of union of the tendon with the cartilage of insertion. He shews that, if we remove the calcaneum with the tendo-Achillis attached from a newly-born rabbit and decalcify the bone by picric acid, longitudinal sections treated by carmine shew a continuity between the tendinous bundles and the basis substance of the cartilage. The cartilage-cells also are seen to be intimately related to the cells of the tendon, and to pass from the former into the latter. Cellular elements having an intermediate form between those of cartilage and those of tendon may be observed. He has also obtained further results by the examination of the union of cartilage and tendon by polarised light. M. Ranvier believes that the varied shapes exhibited by the cellular elements of tendon and ligaments is due to their tendency to revert to their primitive cartilaginous nature.

G. Thin gives A CONTRIBUTION TO THE ANATOMY OF CONNECTIVE TISSUE, NERVE, AND MUSCLE, WITH SPECIAL REFERENCE TO THEIR RELATION TO THE LYMPHATIC SYSTEM (*Proc. Royal Society Lond.*, No. 155, 1874).—He first refers to a memoir which appeared in the *Lancet* (Feb. 14, 1874), "On the Lymphatic System of the Cornea," in which he stated that by the action of nitrate of silver the straight canals, in which the nerves lie, may be seen to communicate with the lacunæ in which the branched cells lie, and that both are lined by flat cells. Since, then, by the action of hæmatoxylon and a saturated solution of caustic potash at a high temperature (105° to 115° F.), he has obtained further results. With the former he found that the nuclei were many times more numerous than he had been led to believe from the examination of gold preparations, thus affording a clear proof that other cells, besides the cornea-corpuscles, exist in the cornea. With the latter, and after he had removed the epithelium from both surfaces of the cornea, he discovered numbers of flat cells of very varied shape throughout the whole fibrillary substance; these he describes very minutely both individually and in mass. He sums up his observations upon the cornea by stating that he believes it to consist of:—"(1) Fibrillary ground-substance pierced by straight canals and honey-combed by cavities, (2) flat cells covering the bundles and lining the cavities, (3) cornea-corpuscles, (4) nerve-structures." The cornea-corpuscles and the nerves occupy the canals and cavities, and between them and the flat cells there is a fluid interval which permits the passage of lymph-corpuscles; and he considers that the continuity of the superficial epithelium with the deep flat cells affords a sufficient basis for the belief that the intercellular spaces of the epithelium communicate with the lymph-spaces of the ground-substance. He next shews that these facts are not confined to the cornea alone, but hold good with other connective tissues. In tendon, when treated by nitrate of silver, he finds that its entire surface is invested by large flat cells, over the surface of which he has observed lymphatic capillaries. Hæmatoxylon gives results similar to those observed in the cornea, and the nuclei are especially abundant between the bundles. As regards the fibrillary substance, he has proved with the potash solution that long narrow cells, similar in shape to certain of the deep corneal cells, invest the primary bundles. The branch-cells he considers to be analogous to the branched corneal corpuscles, and, like them, to occupy the interstices between the bundles. In the skin he also found flat cells, and the relation of these to the lymph-spaces he believes to be the same as in the cornea. Anastomosing branched cells likewise exist between the bundles of fibrillary tissue in the skin, and he is of opinion that all elastic tissue is formed upon the surface and processes of these cells. This theory he defends at some length. In fasciæ, the surface, like that of tendon, when treated by nitrate of silver, shews large flat cells, whilst branched cells are occasionally observed on changing the focus.

He then discusses nervous tissue, and shews that each bundle of fibres is surrounded by a lymphatic sheath. Further, he has been able to prove by the potash solution, that a number of extremely fine long and pointed flat cells are in immediate contact with the medulla, and internal to the sheath of Schwann; and he states that appearances indicate that this latter is also lined by flat cells. He also describes how the nuclei of these cells may be seen by the use of hæmatoxylon. He believes that the axis-cylinder is in intimate relation with the lymph within the sheath of Schwann through the "rings of Ranvier." In the general and special perimysium of muscle he has found a continuous layer of flat cells of large size, the nuclei of which are seen in hæmatoxylon preparations. The potash solution removes all trace of perimysium, and when kept for an hour at a temperature of 110° F., and then allowed to cool gradually, we find that some of the fibres present on their sarcolemma quadrangular nucleated cells, and at other places nuclei. The sarcolemma of muscle is thus also invested by flat cells. Further, by the action of potash we sometimes see a fibre smooth and unaltered, and still shewing some trace of striæ, channelled by a longitudinal canal, or presenting vacuoles on the surface. These correspond to nuclei, which the potash has dissolved. In using gold and hæmatoxylon, he has found that whilst the former only stained the nuclei of branched cells, that the latter stained both these and the nuclei of the flat cells. Longitudinally the muscular fibre is seen to consist of parallel bundles separated by dilatable spaces, in which we see at intervals oblong nuclei, the long axis of which corresponds to that of the fibre. A transverse view shews a number of stellate spaces containing nuclei, branching out from which is a network of fine dark lines, dividing the substance of the fibre into compartments. Amongst the fibrillæ of a muscle deeply tinged by gold, long flat cells are seen occasionally. In short, a muscular fibre consists of bundles, similar to those of tendon, each composed of fibrillæ, and between the bundles are interspaces lined by flat cells. A nerve passing through the perimysium enters the sarcolemma, thus bringing into communication the lymph-space in the interior of the sarcolemma with that beneath the perimysium.

In the *Edinburgh Medical Journal* for September, 1874, Thin gives a further contribution to the minute Anatomy of Muscle and Tendon. In this he states that the primary bundle of a muscular fibre consists of fibrillæ of uniform size (12 to 15 in number in the frog) embedded in an amorphous substance. On the surface of this bundle, as in tendon, there is an investment of long narrow flat cells. These cells are mentioned in the foregoing paper as lying amongst the fibrillæ. A secondary bundle is composed of several primary bundles, and on its surface are rounded or oblong cells. The sarcolemma clothed by quadrangular flat cells surrounds the secondary bundles. When a fibre is treated with gold and an excess of acetic acid it is seen to be traversed in its longitudinal axis by numerous fine elastic filaments, which present oval swellings at certain intervals, and run parallel to one another. Other constituents, however, enter into the formation of a muscular fibre, for when it is broken obliquely we find small triangular masses of protoplasm with anastomosing branches. These form a network, in each mesh of which lies one primary bundle, thus corresponding to the "four-cornered fields" described by Cohnheim in a transverse section of a frozen muscle. In addition to these small protoplasmic cells we notice branched cells of a larger type, which anastomose with each other and with the former, and inclose in their meshes the secondary bundles. The branches of the network are smooth and glistening, and present the other characteristics of elastic tissue, and they communicate with the oval swellings on the elastic filaments which traverse the fibre longitudinally.

He next describes a very peculiar effect produced by the combination of gold and an excess of strong acetic acid. From the open end of the sarcolemma an immense number of rounded punctated discs are seen to flow. These cover the field—some lying singly, others in circular groups. In the mouse these discs are about the size of a human blood-corpuscle. He considers this phenomenon explained by the action of the acetic acid causing swelling of the primary bundles, and as the elastic network is not affected by the reagent it resists this expansion and cuts the contents of the meshes into discs. The single discs correspond to slices of the primary bundles, and the circular groups correspond to slices of secondary bundles. When a muscular fibre is treated by carmine and strong acetic acid we may notice fine elastic filaments encircling and constricting the sarcolemma, and he considers that it is due to these that the large transverse cleavage takes place when the muscular fibre is treated with acids. These elastic filaments spring from nuclei, surrounded by some remains of cellular protoplasm. In chromic-acid preparations, when a single fibrilla of muscle (by which he understands a fine uniform cylindrical thread) is isolated and examined by the immersion-lens, we often fail to recognize any trace of striæ. But with gold the striation is always indicated, which he believes to be due to the more deeply-coloured intermediary substance adhering to the fibrilla in a greater or less degree. As regards tendon, he states that in addition to the flat cells clothing its surface, and described in the former paper, quadrangular flat cells are to be found in its substance investing the secondary and tertiary bundles. These are seen in longitudinal sections of the tendons of œdematous limbs of frogs when treated by chloride of gold, and they are to be regarded as the analogues of the quadrangular cells which lie on the surface of the thicker layers of cornea substance. When the section happens to pass between two bundles a double layer of cells is observed to form a continuous investment around the bundle. In chromic-acid preparations of fœtal tendon we notice that the primary bundles are invested by long narrow flat cells of uniform size, arranged longitudinally, and applied regularly the one to the other, so as to form a very complete covering. These cells are of the same form as those which invest the primary corneal bundles, and it is possible to isolate them by the potash solution from the tendo-Achillis of the frog. On transverse section in gold preparations we see branched cells of the larger type occupying the stellate spaces between the bundles. The branches present the characters of elastic fibres, and form a network, in the meshes of which the bundles lie. The fibres pass longitudinally, however, as well as transversely, and by lying on the surface of the quadrangular cells investing the secondary and tertiary bundles, they give rise to the appearance known as Boll's fibre. Thin believes that around the individual bundles of the primary, secondary, and tertiary order, there is an extremely fine elastic membrane upon which the cells lie. This is shewn by the fact that we occasionally see groups of cells falling off from the bundles and still maintaining their coherence; also in some cases when the tendon has been hardened by chromic acid we may see a fine line distinct from and surrounding the transverse section of a primary bundle. Carmine proves its existence in the secondary bundles, and by adding concentrated acetic acid to a transverse section the intermediary substance of the tertiary bundles swells whilst the membrane does not, and thus the membrane is obscured by the swollen intermediary substance at one focus, but is brought into view by lowering the focus. This membrane is thinner and has not the distinctive glistening appearance of the elastic filaments, and he considers Descemet's membrane and the sarcolemma of a muscular fibre to be nothing else than a modified form of it. In osmic-acid preparations the separate primary bundles of tendon are seen to be direct continuations of the primary bundles of muscle. Both the membrane investing the tertiary bundles and the sheath covering the tendon are composed of a double layer of cells separated by intermediary substance. Similar cells to those investing the primary bundles may be found in the skin, mesentery, cornea, fasciæ, &c.

In the latter part of the paper he discusses the propriety of applying the term "epithelium" to the flat cells, and adds a note upon the branched cells of the cornea. The straight lines hitherto described as passing from the corpuscle he is satisfied are simply a deposit of colouring matter in Bowman's tubes and interfibrillary spaces. He figures a branched cell seen in a horizontal section of the fresh cornea of an ox. The processes are slender, thread-like, and curved, and they anastomose freely with each other. The nucleus, nucleolus, and protoplasm, are very visible.

EPITHELIUM AND ENDOTHELIUM.—Michael Foster (*Quart. Journal Mic. Science*, July, 1874) objects to the use of the term Endothelium, first, on the ground of its etymology, which he characterizes as being of the "most grotesque kind," and, in fact, "pure nonsense." His first used the term to distinguish the epithelium lining the vascular, lymphatic and serous cavities, from the true epithelium of a mucous membrane, and the word *epithelia* or *epithelida*, from ἐπι and θηλη, or 'papilla' or 'mamilla,' was introduced by Ruysch to designate the cuticle of the prolabium and the inside coating of the cheeks. Epithelia in course of time became converted into epithelium, and thus it literally means "that which covers a papilla." Consequently endothelium means "*that which is inside a papilla.*" In the second place, he objects to the term because it cannot be employed to denote the epithelium derived from the elements of the mesoblast, for in that case cells still called epithelium and not differing essentially from the hypoblastic epithelium, viz. those lining the Wolffian and Müllerian ducts which are of mesoblastic origin, would be included under the heading endothelium, and the word would lose all its practical utility. Again, he urges that the continuity exhibited between the peritoneal epithelium and that of the lymphatics is no reason why they should be included under the same term, seeing that we find continuity everywhere.——In the October number of the same *Journal*, Cavafy, in reply, states that the etymology of the term is not so absurd as Foster would have it. *Endothelium* is simply a contraction of *endo-epithelium*, and means an internal epithelium. It is therefore a misnomer only in so far that it covers a surface devoid of papillæ. As to Foster's second objection, he holds that, whilst the mesoblastic origin of endothelium is undoubted, the fact that epithelium is ever derived from the same source must be received with considerable hesitation. From the fusion which takes place between the mesoblast and epiblast in the region of the axial cord of His, we are justified in maintaining that the genito-urinary epithelium is derived from the one as from the other. Again, gland-formation and secretion are characteristics present in epithelium, and altogether absent in endothelium. In the third place, Dr Cavafy points to the intimate relationship which exists between connective tissues and endothelium; how the protoplasm of the connective-tissue corpuscle becomes flattened, and ultimately converted into an endothelial plate—every transition stage between the flattened corpuscle in the lymph-spaces and the cells forming the wall of lymphatics being observed. "Convertibility" therefore, in addition to "continuity," he considers as a ground for the grouping of these cells under a distinctive term. He asserts that it is very improbable that any such connection exists between the connective tissues and epithelium.——In a memoir on the DEVELOPMENT and PROLIFERATION of ENDOTHELIUM and EPITHELIUM (*Schultze's Archiv*, x, 351), J. Zielonko contends that a new formation of epithelium and endothelium can take place in lymph, and that in it also 'giant cells' can be formed out of epithelial and endothelial cells. The growth of epithelium and endothelium in a lymph-sac ensues without being participated in by the cell-elements of the blood-vessels and of the blood.

NERVOUS SYSTEM.—Axel Key and G. Retzius describe (*Nordiskt Medicinskt Archiv*, 1874, 1st part) THE RELATIONS OF THE SUBARACHNOID SPACES TO THE CEREBRAL VENTRICLES and the STRUCTURE OF THE SUBARACHNOID TRABECULÆ. They begin by referring to their former memoirs in which they had demonstrated that all the subarachnoid spaces throughout the entire brain and spinal-cord were in free and uninterrupted communication;—that the perivascular spaces around the blood-vessels in the pia-mater were nothing else than subarachnoid spaces in complete communication with the others;—and lastly, that the epi-cerebral and epi-spinal spaces described by His as lying between the pia-mater and the brain and spinal-cord do not exist in reality, but are produced artificially—the pia-mater which enters the brain with the blood-vessels sending some funnel-shaped prolongations, which are thus immediate prolongations of the subarachnoid spaces continued into the interior of the brain, and forming the sheaths of the vessels. The contents of those sheaths are nothing else than the general cerebro-spinal fluid which is able to pass freely in and out from the subarachnoid spaces. They also state that they have further proved in their preceding papers that the subarachnoid cerebro-spinal spaces are in free communication with the serous spaces and lymphatic spaces of the organs of sense, and that throughout the entire peripheral nervous system, even to its extreme ramifications, a serous system is found, which, by means of the ganglia and nerve-roots, is in free communication with the central subarachnoid spaces.

In this their latest paper they endeavour to prove that the ventricles of the brain are not shut off from this great and universal serous system of the nervous system. They describe no less than three openings which place the ventricles in free communication with the subarachnoid spaces. No connection exists between the ventricles and the subdural spaces, *i. e.* the space under the dura mater.

Of the three openings, one is situated in the middle of the floor of the fourth ventricle in front of the *Calamus Scriptorius*, and is called the foramina of Magendie, from its first discoverer. To demonstrate this aperture they employed injections consisting of a coagulable material, which, after it had coagulated, shewed an uninterrupted communication between the external subarachnoid space through the foramen of Magendie, and all the ventricles, whether the injections were made from the ventricles or from the subarachnoid spaces. The other two apertures are situated anteriorly at the extremities of the *recessus laterales* of the fourth ventricle, and at the internal part of the *flocculus*, and at the anterior border, ordinarily in a half-moon, of the floor of the fourth ventricle. These lateral openings have a valvular character, and seem more for the outward passage of fluid than for its entrance. Through them, as also through the foramen of Magendie, passes the choroid plexus, which they constrict to a certain extent. It is only on removal of the vagus and glosso-pharyngeal nerves that the lateral apertures are well seen as these lie in front of them and partly hide them. On one occasion the foramen of Magendie was found occluded by a membrane, and the authors do not doubt that the lateral openings may also be occasionally shut, but still they have never observed a case in which this was so. Finally, they point to the great significance of these three apertures both in a physiological and a pathological point of view—how unhealthy products can pass from the ventricles into the external cerebro-spinal spaces, and *vice versa*, from these last into the ventricles, and how the ventricles can be dilated by a fluid formed outside themselves, or again, how an occlusion of any of these three openings of the fourth ventricle would lead to the retention of fluid and a consequent expansion of the ventricles.

By these investigations and by the former papers of the authors, therefore, it is demonstrated that a continuous serous system pervades the entire nervous system from the ventricles of the brain, the subarachnoid spaces, and the sheaths of the vessels in the brain and spinal cord, to the extreme ramifications of the peripheral nervous system.

Their memoir upon the subarachnoid tissue is supplementary to their former papers upon the same subject, in which they had proved that all the free trabeculæ are surrounded by a sheath of thin, flat, coherent cells. Now they give a description of certain fibres which are occasionally found surrounding the fibrillary fasciculi of these trabeculæ. It is only in certain of the subarachnoid trabeculæ, when examined fresh and in an indifferent fluid, that we can recognize any trace of striæ. These may be very indistinct, but in other cases they are so evident that we can distinguish true filaments of greater or less tenuity, and which, more or less numerous and closely appressed, are rolled round the trabecula: often obliquely to its long axis, superficially to this fibrillary network, the sheath of flat cells is found. On adding acetic acid the trabeculæ rapidly swell, and the circular fibres, before imperfectly seen, stand out most distinctly, giving rise to constrictions of greater or less depth in the swollen trabecula. They may assume an annular or spiral arrangement around the trabeculæ—sometimes they even form a coherent network. They do not swell themselves by the action of the acetic acid, and thus they resemble elastic fibres. When the subarachnoid trabeculæ form networks or membranes more or less cribriform, we may find them covered by these filaments, but it is not rare to find trabeculæ entirely devoid of them. When hardened by hyperosmic acid they are more distinct than in the fresh state, and sometimes they are of considerable size, and present here and there swellings. But the individual trabeculæ, each surrounded by circular filaments, and a sheath of flat cells, may, on uniting into fasciculi, be seen to be invested by a common network of such filaments. Sometimes we find an external row of trabeculæ enveloping the primitive fasciculi in the form of a network, and in other cases they have demonstrated that in some forms of cellular tissue thin membranes with elastic fibres are spread upon the external layer of flat cells. We observe a similar arrangement in the trabeculæ in question. But in addition to these trabeculæ encircled by elastic fibres, the authors have found another kind in the subarachnoid tissue at the base of the brain and of the cerebellum, and also of the pons Varolii and medulla oblongata. In these the fibrillary bundles are surrounded by a thick, clear, or homogeneous mass, in which we observe at varying intervals granular points. On close examination we find these to be nothing else than the cut ends of the encircling filaments arranged in layers which vary in number. On looking at the superior or inferior surface of the trabeculæ, we observe the closely appressed striæ around them They give to the trabeculæ the appearance of bundles of longitudinal fibres enveloped in tow. This thick mass ought to be considered as a peculiar fibrillary sheath belonging to the trabecula. The external surface is strictly limited; it is covered by a membrane of flat cells which can be, here and elsewhere, easily detached.

The fibrillary sheath varies in thickness, and even along the same trabecula we may sometimes observe knotty enlargements and thin portions alternately. As a general rule the filaments have a circular arrangement around the trabeculæ, but it is by no means uncommon to see them taking an oblique or spiral course. However, upon the same bundle they usually keep the same direction. There are likewise, however, longitudinal filaments of a similar character, and sometimes we may observe alternating layers of longitudinal and transverse filaments with nuclei interposed between them. Such a fibrillary sheath can enclose several bundles which may branch and then reunite, but they are always invested by the sheath. The fibrillæ in the sheath are seen in the fresh state, but they stand out better when treated by hyperosmic or chromic acid. When treated by acetic acid they do not swell like the cellular tissue-fibres, but, on the other hand, they are not rendered more distinct like elastic fibres. On the contrary, they become less plain and paler.

What relation have these fibrillæ to the true, elastic, encircling fibrillæ? Sometimes we observe fibrillæ of both kinds upon the same trabeculæ. In that case the fibrillary sheath is superimposed upon the fibrillæ of the first order, which we are often able to distinguish lying beneath the sheath and upon the fibrillary fasciculus. When we add acetic acid the fibrillary sheath prevents the bundle from swelling. In some cases we may find trabeculæ provided by a fibrillary sheath in the midst of other trabeculæ of cellular tissue, and sometimes the two varieties enter together into the formation of networks and cribriform membranes.——In a chapter contributed to Bucknill and Tuke's treatise on *Psychological Medicine*, London, 1874, J. Batty Tuke enters into the histology of the brain, and, amongst other facts, enquires into the minute distribution of the BLOOD-VESSELS TO THE CONVOLUTIONS. He shews that the larger arteries go directly to the white matter, rarely throwing off branches on their way; that when they have passed through the grey matter they branch off almost at right angles, and follow the direction of the inner layer of grey matter. Two sets of vessels supply the grey matter: the innermost layers by smaller branches than those to the white matter, but the outer layers receive straight arterioles, small in size, and not giving off many branches.——M. Duret gives a contribution to the ANATOMY OF THE CEREBRAL BLOOD-VESSELS (*Arch. de Phys.* 1874, 316). He first discusses the distribution of the arteries in the pia-mater, describes in detail their method of branching, and contradicts the prevailing opinion that a rich network of anastomosing vessels is to be found in the pia-mater on the surface of the convolutions. That anastomoses exist in the pia-mater, to a certain extent, he does not deny, for he has proved by injections that, at the periphery and at the confines of their distribution, the anterior, middle, and posterior cerebral arteries of the same side communicate the one with the other. In addition the posterior cerebrals have a slight communication in the middle line, but the other two arteries are in no way connected with the corresponding vessels of the opposite side except by the anterior communicating branch. He next gives the results of certain researches into the arrangement of the vessels in the fœtal brain when its surface is smooth and devoid of fissures. The arteries are then regular and rectilinear, and arterioles pass off perpendicularly to enter the cerebral substance. When the surface of the brain increases by the appearance of sulci the arteries follow this development. They cannot pass from one convolution to another without dipping down into the sulcus, for they are held in relation to the nervous substance by little arterioles. The principal branches do not increase much at their extremities, but rather undergo an elongation and increase by the multiplication of the elements composing their coats. On the other hand, the smaller branches develope and produce collateral arterioles. He states that, although hitherto no one has attempted to trace the limits of the distribution of the cerebral arteries, all his observations point to the fact that the district supplied by each artery is very definite and constant. He gives an elaborate description of the distribution of the branches of these vessels, and gives them names according to the position they occupy or the convolutions they supply. He next discusses the arrangement of the veins in the pia-mater, and shews that a free communication exists between those of the convexity and those of the base through the medium of a large vessel, the "great anastomotic vein," so called by M. Trolard, who first described it. This vein passes from the superior petrosal sinus to the fissure of

Sylvius. Another branch of anastomosis may also be found, called the "anterior basilar vein." This springing from the great anastomotic vein joins the posterior basilar vein which ends in the straight sinus. Very often a true venous circle is formed within the circle of Wallis by the posterior basilar vein communicating with its fellow of the opposite side. Duret states that the communications which exist between the veins of the convexity, although undoubtedly very numerous, have been much exaggerated by the greater number of authors. M. Duret now follows the arteries as they pass from the pia-mater into the cerebral substance, and gives in detail their arrangement in the grey and white matter of the convolutions. The medullary arteries, *i. e.* those which go to the white matter, spring at right angles from small branches in the pia-mater, and in the section of a convolution of medium size we may observe from 10 to 15; they are almost rectilinear in the adult; those which penetrate the free surface, in number from 3 to 4, are perpendicular to it; some pierce the contiguous surfaces of the convolutions obliquely; within the grey layer they bend so as to become parallel to the principal bundles of white matter; others follow the direction of the commissural fibres of the convolutions; lastly, near the sulcus we frequently notice a group of 5 or 6 arterioles, which, diverging, spread amongst the white matter, and these go to supply the most distant parts of the centrum ovale. The medullary arteries rarely divide into large collateral twigs, but in passing through the grey matter they give off a few delicate branches, as also at the point of junction of the white and grey matter. In the white matter they give off the twigs which, by complex anastomosis, constitute the capillary networks. The cortical arteries, *i. e.* those which supply the grey matter, are the terminations of those twigs in the pia-mater which are developed at the same time and in proportion with the grey matter. The most minute of these vessels end in the grey substance—others, however, go to its point of junction with the white substance. They rapidly resolve themselves into capillary networks.

As to the capillary networks Duret states that we can recognize four varieties: (1) the first occupies scarcely half a millimetre of the most superficial part of the grey substance. It is best seen in horizontal sections, and the meshes are large, quadrangular, and parallel to the surface. (2) This extends for two millimetres below the first, and the meshes, which are very fine, have a polygonal form. The cortical arteries are innumerable. The region of this network corresponds to the layer of grey matter in which the large cortical cells are found, and in this way may we account for its great vascularity. (3) This constitutes the network of "transition," and it occupies the last millimetre. The meshes are larger than those of the superior layer, but are much less elongated than those of the white substance, with which it is continuous. (4) This is the network of the white substance, and is formed of meshes whose long diameter is three or four times greater than that of the meshes in the grey substance. The meshes seem to surround the principal bundles of fibres, and the network is arranged in the direction of these fibres.

With regard to the intra-cerebral veins, Duret shews that the medullary spring from small venous branches in the pia-mater, and do not exceed 6 to 8 in number in a section of a medium-sized convolution. They do not accompany their corresponding arteries. We generally find one or two piercing the surface of the convolution perpendicularly. Four or six penetrate by the lateral surfaces, and they have a calibre three times as great as that of their corresponding arteries. In passing through the grey matter they give few collateral offshoots, but at the lower limit of this layer they give three or four recurrent branches, which seem to act as outlets for the blood in the network of *transition*. Duret states that in successful injections of the arteries and veins, the two first capillary networks of the grey matters are coloured red, whilst the network of transition is coloured blue, and the network in the white substance partly red and partly blue. This, he considers, proves that the return of the blood from the networks of the grey matter takes place chiefly through the medium of the transition network and the recurrent branches of the medullary veins. The blood therefore tends to stagnate in the grey matter. The medullary veins pass deeply into the centrum ovale, and Duret considers that they communicate with those of the ventricles, as he has injected the venæ Galeni through one of the cortical veins. He states that the cortical veins are larger and less numerous than the corresponding arteries, and that they rarely terminate in the first two capillary networks. They ramify almost exclusively in the network of transition. Duret next argues that Ecker is altogether wrong in supposing that a direct anastomosis exists between the veins and arteries in the pia-mater or in the cerebral substance. All his researches go to prove the opposite.——Burt G. Wilder, in a *Collection of papers, chiefly Anatomical*, Salem, Mass., 1874, writes an interesting paper on the outer CEREBRAL FISSURES OF MAMMALIA, especially the Carnivora, and the limits of their homologies; also a paper on CEREBRAL VARIATION IN DOMESTIC DOGS, and its bearing upon scientific phrenology. These papers are illustrated by several useful wood-engravings.——A. Pawlowsky, a pupil of Meynert's, gives an account (*Siebold u. Kölliker's Zeitsch.* 1874, 284) of the COURSE OF THE FIBRES OF THE POSTERIOR COMMISSURE. He states that it consists of nerve-fibres, descending from the brain, and crossing over to the tegmentum of the crus cerebri. These fibres have a fourfold origin: (*a*) in the pineal body; (*b*) in the frontal lobes through the anterior peduncle of the optic thalamus; (*c*) in the temporal lobes and in the Sylvian fossa through the lower peduncle; and (*d*) probably in the thalamus itself. One part of the fibres extends in the track of the tegmentum, another lies on its inner aspect. Commissure-like or arcuate fibres do not exist in the posterior commissure.——P. Schiefferdecker writes (*Schultze's Archiv*, x. 471) on the COURSE OF THE FIBRES IN THE SPINAL CORD. He recognizes five chief modes of arrangement: (1) fibres which pass from some point at the periphery to ganglion cells; (2) fibres which go between groups of ganglion cells; (3) fibres which pass from a point at the periphery into a commissure; (4) fibres which pass vertically in the grey matter to connect parts situated in different transverse planes; (5) fibres which remain in the same half of the cord, and pass direct from one part of the white substance to another.——A. Lubimoff relates (*Virchow's Archiv*, LXVI. 217) his embryological and histological researches into the SYMPATHETIC AND CEREBRO-SPINAL NERVOUS SYSTEMS, and in LXI. p. 145, contributes a memoir on the histology and pathological anatomy of the sympathetic nervous system.——H. C. Major relates further (*West Riding Asylum Reports*, IV. 223) observations on the HISTOLOGY OF THE MORBID BRAIN. The condition of the cortical substance in cases of senile atrophy is especially considered.——Finkam investigates (*Reichert u. du Bois Reymond's Archiv*, 1873, 721) the mode of TERMINATION OF THE NERVES in the GREAT OMENTUM.

ALIMENTARY CANAL.—Herbert Watney (*Pro. Roy. Soc. London*, No. 152, 1874; also in *Centralblatt*, 1874, No. 48) gives a contribution to the MINUTE ANATOMY OF THE ALIMENTARY CANAL. He states that amongst the epithelium of certain parts of the alimentary mucous membrane of many animals connective tissue may be found forming a delicate reticulum, in whose meshes nuclei, situated between and below the epithelial cells, and sending processes to the free surface, are occasionally seen. Round lymphoid cells may also be observed. A similar intra-epithelial reticulum exists in the pyloric glands of the stomach and the crypts of Lieberkühn. The epithelium of the mucous membrane of the tonsils and Peyer's glands is infiltrated by a delicate reticulum of nucleated cells, in whose meshes lymph-corpuscles are to be found, and this tissue is in direct continuity with the adenoid tissue in the corresponding follicles. He states that the lining endothelium of the lymph-vessels in the mucosa being in direct continuity with the reticulum, may be considered as being derived from the connective-tissue corpuscles. He further describes how, when animals are killed during the absorption of fat, the oil-drops coloured black by osmic-acid may be seen: (1) in rows between and around the superficial epithelial cells; (2) in the reticulum at the base of the epithelium; (3) in the connective-tissue stroma of the villi, from whence they penetrate into the lymph-vessels. This seems to shew that the fat-drops are not taken up by the epithelial cells, but by the intervening processes of connective tissue. Through the medium of these they reach the central vessel, whose wall stands in continuity, as above mentioned, with the reticulum of the villus. The blood-vessels and the muscular tissue receive special sheaths from the reticulum of nucleated cells. In the papillary processes of mucosa of the pylorus the blood-vessels possess very vascular lymph sheaths, whose walls are composed of connective-tissue cells arranged like endothelial plates.——J. Custor enters (*Reichert u. du Bois Reymond's Archiv*, 1873, 478) into a comparative examination of the RELATIVE SIZE OF THE INTESTINAL CANAL to the chief organic systems in the bodies of man and mammals.

THE TEETH.—E. Magitot describes (*Robin's Journal*, 1874, 255)

Anomalies of Dentition in Mammals under the following heads: definition, classification, and statistics; their characters in the mammalian series, in which he denies the presence of rudimentary incisor follicles in the upper jaw of ruminants; anomalies in the races of men: their mode of production, their pathological and surgical relations. On p. 422 he considers anomalies in the seat of production of the teeth, or heterotopia.——Paul Gervais describes (*Journal de Zoologie*, II. 1873, p. 499) the DENTITION OF A FŒTAL NARWHAL, almost at the full time, in which not only were the two usual teeth apparent and in part dentified, but two others were found placed behind the first-named, one on each side, and some *m. m.* in length. These rudimentary teeth were somewhat pisiform, and their bulb was ossified. They were caducous. These teeth were obviously a more advanced stage of the rudimentary teeth described by W. Turner in a younger narwhal fœtus in this *Journal*, November, 1872.

LIVER.—Ch. Legros (*Journ. de l'Anat. et Phys. March and April*, 1874, 137) gives the results of some researches into THE STRUCTURE AND THE EPITHELIUM OF THE SECRETORY BILE-DUCTS. He states that after the successful injection of a rabbit's liver with gelatine and nitrate of silver the extra lobular bile-ducts may be seen to be lined by a very distinct prismatic epithelium. From these ducts proceed branches which, anastomosing amongst themselves and with the branches of neighbouring ducts, form an interlobular network with large meshes. The interlobular secretory canals arise from this, and they constitute the origins or terminations of the secretory biliary passages. The terminal network in the interior of the lobule is formed by these latter. Each mesh of this is small and regularly polygonal, and encloses a hepatic cell. It is thus easily distinguished from the capillary network, the meshes of which are very large and elongated. Further, the biliary canals are much finer than the capillaries, and maintain the same calibre throughout the entire lobule. He further states that in the interlobular canals the epithelium is not so precisely prismatic as in the extralobular canals, whilst in the intralobular passages it assumes a tesselated character, and the wall is formed by thin cells placed in accurate juxtaposition. Sometimes fine canals may be observed lined by cells larger than the calibre of the canals, so that the latter are obliged to bend upon themselves and follow the concavity of the vessel. M. Legros considers that his researches prove the existence in the liver of a great glandular network, constituting a *reticulated gland*, whose special function is the production of bile. The hepatic cells included in the meshes of this biliary network have other functions, being most probably concerned with the formation of glycogen.——G. Asp communicates (*Ludwig's Arbeiten*, 1874, 124) a memoir on the ANATOMY AND PHYSIOLOGY OF THE LIVER. He investigated the liver of rabbits, both after starving and feeding these animals, and found that it contained cells devoid of nuclei. He saw in the walls of the smaller gall-ducts a cylindrical epithelium as usually recognized, outside which was connective-tissue containing numerous fusiform nuclei. The interlobular bile-ducts gave off numerous branches into the lobules which lay amidst the cells, but these intralobular ducts had no cylindrical epithelium, or defined wall of connective tissue, but only a layer of flat cells with fusiform nuclei.

SKIN.—J. Neumann publishes a *pamphlet, Vienna,* 1873, on the LYMPH-VESSELS OF THE SKIN. He describes them as forming a closed tubular system, with independent walls lined by a flat epithelium, without stomata, and having no communication with juice-canals or other interstices in the tissue of the cutis, or with spaces between the epithelial cells. The lymph-vessels lie deeper than the blood-vessels, and form in the cutis a superficial and a deep network. The lymph-vessels enter the papillæ, partly as simple tubes, partly as loops. The hairs, hair-follicles, and sweat-glands, possess their own lymph-vessels, which do not, however, enter the follicle; the fat-lobules are also surrounded by them. They are most numerous in the scrotum, labia majora, the hand and sole.

URETHRA.—MM. Robin and Cadiat (*Journ. de l'Anat. et de la Phys. Sept. et Oct.* 1874, 514) describe THE STRUCTURE OF THE MUCOUS MEMBRANE AND OF THE GLANDS OF THE MALE AND FEMALE URETHRA. They assert that the simple clusters of glands, and even the follicles of the spongy and membranous portions of the male urethra are of the same type as the prostatic acini, and that they represent the glandular elements of the prostate, separated the one from the other. On the other hand, the prostate in reality consists of a congeries of these elementary parts. Further, in the female urethra only these dissociated glandular parts are found, and they exist in comparatively fewer numbers than their analogues in the male urethra. In this latter the simple glands do not exist in the mucous membrane, and do not open on the surface by other ducts than by those of the prostate, and in the prostatic region.

EMBRYOLOGY.—F. M. Balfour gives (*Athenæum,* Aug. 29, and *Quart. Jnl. Mic. Sc.* Oct. 1874) a preliminary account of the DEVELOPMENT OF ELASMOBRANCH FISHES. Firstly, although as large a quantity of food-yolk is present in the shark's egg as in the bird's, yet throughout the egg of the shark there is a fine network of lines, such as are found in many cells, while scattered through it, especially around the germinal disc, were a number of nuclei. From the presence of these lines and nuclei, it is to be concluded that the whole of the yolk, including both the germinal disc and the food-yolk, are to be looked upon as a single cell, the ovum, in the greater part of which passive food-yolk granules are embedded. Secondly, in the mode in which its alimentary canal is formed the shark is intermediate in condition between the frog and the bird; for, although its alimentary canal is not formed by an involution, as in the frog, still traces of the primitive mode of formation of the alimentary canal by an involution are retained in the shark, though lost in birds. The most important of these is the continuity at the hind end of the embryo between the epiblast (outer layer) and the hypoblast (inner layer), which results in the neural and alimentary canals, subsequently communicating with each other behind, as is the case with frogs and other vertebrates whose alimentary canal is formed by an involution. Thirdly, in sharks the notochord is formed as a thickening of the hypoblast, and not derived, as in all other vertebrates hitherto described, from the mesoblast.——E. Ray Lankester makes (*Athenæum*, Sep. 5, 1874) some Observations on the DEVELOPMENT OF THE EYE IN THE CUTTLE FISH. He instituted a comparison between the eye of the vertebrate and cephalopod, and shewed how radically they differ in development. Yet he was inclined to believe that they might ultimately be traced to a common origin. In Loligo and Sepia the eye originates as a raised elliptical wall on the surface of the embryo. The wall closes in above, and thus the primary optic vesicle is formed. From the front of this arise new wall-like growths, forming an anterior or second optic vesicle, cornea and iris. The lens, curiously enough, is secreted from the cells of the anterior wall of the primary optic vesicle, and is quite free from cell-structure. It is a cuticular formation, such as the bristle of an annelid. The cells of the posterior part of the primary optic vesicle become modified, so as to form the two layers of retinal elements. It is important to observe that in Nautilus there is, as Hensen described, no lens, and but one optic chamber. In fact, Nautilus has exactly the arrangement in adult life which is seen in the early condition of the eye of the cuttle-fish, before the wall of the primitive optic vesicle has quite closed in.

MALE ORGANS.—V. v. Mihalkovics contributes (*Ludwig's Arbeiten*, 1874) to the ANATOMY OF THE TESTICLE. He describes the arrangement of the seminal tubes: he states that the supporting cells (*stütz-zellen*) and *keim-netz* are artificial products; that interstitial cells are constituents of the testicle: that the connective tissue of the testicle consists of bundles, which form a network, and are invested by endothelial cells: the origin of the lymph-vessels is in the spaces between the endothelial invested bundles of connective tissue: the capillary blood-vessels lie close to the membrana propria of the seminal tubes. The epididymis is not only a tube for conveying the semen, but also a secreting place for its fluid constituents. The blood-vessels form in its muscular wall a compact capillary network, which lies immediately under the cylinder epithelium, and resembles the vascular arrangement in the ovary.——P. Langerhans describes (*Virchow's Archiv*, LXI. 208) the GLANDULAR STRUCTURE of the prostate, vas deferens, vesicula seminalis, and Cowper's glands.

FEMALE ORGANS.—L. Born contributes (*Reichert u. du Bois Reymond's Archiv*, 1874, 118) to our knowledge of the DEVELOPMENT of the OVARY OF THE MARE.——In the same *Archiv*, 234, Haussmann enquires historically into the UTRICULAR GLANDS.——In the *Abhand. der Akad. der Wiss. zu Berlin*, 1873, C. B. Reichert publishes *in extenso* his memoir on the condition of the HUMAN UTERUS AND EMBRYO in the vesicular stage of development, an abstract of which, published in his *Archiv*, was given in the *Report* for Nov. 1873.

REPORT ON PHYSIOLOGY. By WILLIAM STIRLING, D.Sc., M.B., C.M. (Edinb.), *Demonstrator of Practical Physiology in the University of Edinburgh*[1].

Nervous System.

FUNCTIONS OF THE BRAIN.—*Untersuchungen über das Gehirn*, von Dr Ed. Hitzig, Berlin 1874. These investigations on the brain are the collective papers of the author upon this subject. Most of them have already been published in *Reichert und du Bois Reymond's Arch.*, and have been noticed in previous reports. A chapter is devoted to critical and experimental observations on the physiology of the cerebrum, in relation to the experiments and results of Dr Ferrier. Some pathological papers are added, including the details of an interesting Abscess of the grey matter of the brain; Anomalies of Muscular Innervation; Secondary affections of the nervous system after peripheral injury; On the disturbances of muscular innervation which occur on galvanisation of the head. One chapter is devoted to the equivalent regions in the brain of the dog, of the ape, and of man, and two shorter papers treat of the Physiology of the Cerebellum; and on the production of Epilepsy by experimental injury to the grey matter. [See *Lond. Med. Rec.* No. 78, by Ferrier, and reply in No. 81, by Hitzig.]

ON THE RESULTS OF THE ELECTRICAL INVESTIGATION OF THE CONVOLUTIONS OF THE BRAIN OF AN APE.—E. Hitzig, Berlin. *Klin. Wochenschr.* 1874. No. 6 (from *Abst. in Centralblatt*, No. 24). The experiments were made upon the brain of a living ape, and the author finds that in this animal the proper motor part of the convolutions of the brain is the anterior central convolution, that the single centres lie distributed in it from the great cerebral fissure to the Sylvian fissure. About 3mm. from the median line lies above the centre for the posterior extremity of the opposite side; 3mm. to the side that for the anterior extremity. Removed from this 7mm. is the centre for the part of the structure connected with the optic nerve, and close to the fossa S. the fourth centre, which controls the movements of the mouth, tongue, and jaw, and from which the collective movements which result occur on both sides. The proper parietal and frontal regions were only superficially investigated; there, weak currents produced no movements, and the upper part of the posterior central convolution reacted most easily on the application of strong currents. The anatomical details are to be seen in the original.

THE LOCALISATION OF FUNCTION IN THE BRAIN.—D. Ferrier. Paper read before the *Royal Society*, London, 1874. March 5. The author's experiments on the brains of apes shewed that in general

[1] To assist in rendering this report more complete, authors are invited to send copies of their papers to Dr Stirling, Physiological Laboratory, Edinburgh University.

the centres for the movements of the limbs lie in the convolutions bounding the fissure of Rolando; *i.e.* in the posterior central convolution with parts of the upper lobes, which lie more backwards towards the parieto-occipital fissure, in the anterior central convolution and to the posterior end of the first frontal convolution. In the anterior central convolution at the level of the junction of the middle central convolution lie centres for distinct facial muscles (Zygomaticus et c.). In the angle where the lowest (third) frontal convolution and the anterior central convolution meet lie the centres for the movements of the mouth and tongue. At the lower angle of the Sulcus inter-parietalis is the centre for the platysma. In the first frontal convolution, in front of the centre for certain forward movements of the arms, and in the corresponding part of the middle frontal convolution, lie the centres for the (crossed) head and eye movements and for the dilators of the pupil. The most anterior frontal region, together with the orbital convolutions, yielded no definite results when irritated. Destruction of these parts produced a condition resembling dementia. Stimulation of the gyrus angularis produced movements of the eyeball and pupil. Its destruction destroyed the sense of sight. The sense of smell finds its central ends in the gyrus uncinatus. The seat of the sense of touch could not be made out. The occipital lobes did not react upon stimulation; their destruction seemed to extinguish the sense of equilibrium. Exact localisation in frogs and fishes is impossible; stimulation of the cerebrum produces in frogs movements of the limbs; in fishes movements of the tail and fins. It is interesting that as the single result of stimulation of the surface of the brain contraction of the pupil was observed.

Direct electrical Stimulation of the Corpus Striatum.—J. Burdon-Sanderson (*Centralblatt*, No. 33, 1874). By means of a sharpened spoon the outer and upper portion of the anterior lobe of one hemisphere was so far removed, that the parts lying immediately outside of the anterior portion of the lateral ventricle were exposed, without, however, opening the ventricle. (The anterior horn can be opened without injury.) The deepest part and that lying next the middle line in this prepared surface corresponds to the corpus striatum. When the surface of the c. striatum was stimulated electrically it was shewn: 1. That movements of the muscles of the opposite side occurred upon the application of weak induced currents. 2. That the points where stimulation of the intact surface of the brain was followed by distinct groups of movements, are also present on the surface of the corpus striatum. 3. That the opposite position of the active points is the same on the corpus striatum as on the surface of the brain. If the deepest part of the corpus striatum is stimulated, the animal opens its mouth, puts out its tongue and draws it in again alternately. These are the movements whose centres are pretended to be found on the convolutions of the under surface of the brain, *i.e.* lower frontal and suprasylvian convolutions. (*Lancet*, June, 1874.)

Physiology of the Brain.—Ed. Hitzig (*Centralblatt*, No. 35, 1874). By removal in the region of the posterior convolutions (Gyri.

n. o. Fig. 3 in *Untersuch. über das Gehirn*) blindness of the opposite eye and paralytic dilatation of the corresponding pupil can be produced, while stimulation of the same spot is followed by strong and continued contraction of the pupil. He then refers to B. Sanderson's results and remarks that the localised points on the surface of the brain given by B. Sanderson do not correspond with those described by himself (Hitzig). That he had already shewn that the corpus striatum was excitable, and refers to p. 48–49 of his *Untersuchungen*.

ELECTRICAL EXCITABILITY OF THE CEREBRUM.—H. Braun, *Eckhardt's Beitr. zur Anat. und Physio.* VII. 2. s. A. 16 Str. (From the *Centralblatt*, No. 29, 1874.) The author disagrees with Hitzig regarding the sensibility of the dura mater. According to B. the dura is not a sensitive membrane, and does not become so on being left exposed for a long time. For the experiments non-narcotised dogs were for the most part employed, the surface of the brain being stimulated by weak induced currents. In general, the facts already known (*Journal of Anat. and Phys.* vii. & viii.) were confirmed; the author finds however often the double presence of a centre on the same half of the brain, e.g. for the muscles of the neck. After stimulation with quite weak currents after-movements dependent on the stimulated centre were manifested by the muscles, which movements often passed into general convulsions, but could only be produced from the points which were to be regarded as so-called centra. The assumption that the movements obtained might arise from loop-currents passing into the deeper parts of the brain, the author refutes, by making near the surface, an interrupting section in the course of the fibres in the deeper parts, having previously sought out one of the centres. Now, stimulation of the previously excitable centre gave no result. If the gray substance of the surface which represented a centre was removed, and the white substance so exposed was stimulated, then there occurred with the same position of the electrodes, and the same strength of the current as formerly, movements in the same group of muscles. The bundles of fibres which penetrate into the gray substance are those whose stimulation produces the movements. Regarding Schiff's view that in the movements obtained by stimulating the surface of the brain electrically one has to do with reflex phenomena, the author does not decide either for or against.

ON THE FUNCTION OF THE THALAMI OPTICI.—H. Nothnagel (*Centralblatt*, No. 37, 1874). From many experiments made upon rabbits the author draws the following conclusions: 1. These organs have nothing whatever to do with the innervation of voluntary movements. 2. Quite as little can a direct disturbance of the cutaneous sensibility be proved after their extirpation. 3. On the contrary they seem to stand in a distinct relation to the "muscular sense." Details are promised shortly.

ON THE FUNCTION OF THE BRAIN.—Nothnagel, *Virchow's Arch.* LX. 128. (*Abstract in Lond. Med. Rec.* No. 72, 1874), has continued his researches on this subject, still using the injection of chromic acid. When only one lenticular body was operated on, the results were the following. Deviation of the leg of the opposite side (right) towards the middle line and that of the same side (left) outwards, a lateral curvature of the spine with the convexity turned towards the opposite side (right), and at the same time a moderate cyphosis. The animal could however execute all voluntary movements. A different state of things occurred when both nuclei lenticulares were operated on. In twenty-six cases the author succeeded with the operation, and the results in all cases coincided. Many results were negative, when the chromic acid focus did not lie exactly in both nuclei lenticulares. The introduction of a fine cannula and injection of chromic acid into the nucleus lentic. were not followed by any phenomena of stimulation, the animal remained quite as quiet as if nothing had happened. When the bilateral injection was successfully executed and the animal was placed on the ground, it remained sitting and quite motionless, and when it was not disturbed it remained in this condition for hours together. The animal did not make the least attempt at voluntary movements, and had a stupid and sleepy appearance. The spinal column was sometimes straight; sometimes cyphotic, but never curved laterally. The ears were erect, and never laid backwards upon the neck. The respiration and action of the heart were normal. If the forelimbs were carefully extended so that the animal did not lose its equilibrium, and though the feet might be placed in a very unnatural position, as over the neck, they were not drawn back, as always occurs in the normal animal. Slight pinching of the tail, which a normal animal would not notice, was followed by withdrawal of the foot from the unnatural position, and the animal appeared as if it would spring; but with one spring the movement came to an end, and the animal became motionless as before. The same thing could be repeated over and over again. In some cases the animal sprang four, six, or even sixteen times. The animal sat without making any attempt at spontaneous movement; and if not disturbed, until death occurred; just like an animal from whom the cerebral hemispheres have been removed. Nor did the animals eat of their own accord. Most of the animals died on the second or third day, but six lived till the seventh day and were very emaciated. The *post-mortem* examination showed a circumscribed chromic acid focus of the size of a lentil in each nucleus lenticularis. When the focus was of this size, and was situated in the middle and extended towards the middle line and posterior part of the nucleus, then the characteristic symptoms were produced. If however, the one nucleus was less affected than the other, or if the chromic acid had not affected the nucleus sufficiently in its depth, then the characteristic symptoms were not exhibited. The author has already described the springing movements produced by injury of a distinct spot in the corpus striatum, called by him "nodus cursorius." When both nuclei lenticulares were operated on and the nodus punctured the springing movements could still be produced. In a third series of experiments both corpora striata were operated on. It was difficult to reach these organs and destroy them totally.

The injection method was here inadmissible, because the fluid passed to the fourth ventricle. Their structure was broken up by a fine needle introduced through the skull. When the point of the needle entered the ganglion, the animal sat quite still. In a time, varying from one to two minutes, the animal sprang about violently to one side and to the other avoiding obstacles in its path. The increased sensibility of the auditory and optic nerves remained for a few hours, at the longest for two days. The animal could execute voluntary movements. After a few days scarcely anything pathological was to be observed. The explanation given by the author of the symptoms following injury of the nuclei lenticulares is that by extirpation of these organs, the collective nerve-channels which conduct the motor voluntary impulses from their place of origin—the hemispheres—to the channels lying more posteriorly, and peripherically, are interrupted. According to Meynert's expression the collective psycho-motor paths are divided. Regarding the experiments on the corpora striata, the author is of opinion, and he expresses his view with all reserve and as hypothetical, that the nucleus caudatus stands in relation to all those combined forms of movement which are excited by the psychical processes, but then continue automatically without any new voluntary impulse. Such a movement is seen in the case of laughing, where the play of the muscles lasts for a time after the psychical process which originally excited them, is already extinguished.

Action of Quinine on the Nervous System.—H. Heubach (*Centralblatt*, No. 43) has repeated Eulenberg's experiments (*Reich. und Du Bois*, 1865). The author employed a sub-cutaneous injection of the weak basic Quininum amorphum muriaticum, which is easily soluble in water in the proportion of 1 : 1. The dose injected at once was 0,004—0,015 quin. amorph. mur. The following results differ from those of Eulenberg. 1. Small doses do not diminish but increase the reflex-excitability. 2. By large doses the reflex-excitability is at first increased, and then diminished, still this diminution is to be viewed as a consequence of cardiac paralysis. 3. Very large doses influence not only the respiration and action of the heart, but extinguish very rapidly all signs of life and therewith the reflex-excitability. With regard to the cause of death in poisoning with quinine, the authors find as well in frogs as mammals, that the respiration stops first, and that the paralysis of the heart occurring in consequence can be hindered by artificial respiration. Death from quinine is therefore not due to a direct poisoning of the heart, but in the first rank to paralysis of the respiration, although the heart is also paralysed by quinine though later than the respiration.

"Absence of the Corpus Callosum without disturbance of intellect." Malinverni, *Gazetta delle Cliniche*, No. 15, 1874 (Abst. in *Lond. Med. Rec.* No. 73, 1874).——"Bartholow's Experiments on the human Brain." *Lond. Med. Rec.* No. 71, II. 1874.——"The Physiology and Psychology of Laughing." E. Hecker, Berlin, 1873, 8, 83 pp.; and "Physiologie et Psychologie du Rire," L. Dumont, *Revue*

Scientifique, 1873, III. No. 23.——"Brown-Séquard on the Localisation of Brain Function." *Lond. Med. Rec.* No. 74, 1874.——"Estimation of the Capability of Reaction in the Brains of the Insane." H. Obersteiner, *Virch. Arch.* LX. (Abst. in *Lond. Med. Rec.* No. 74, 1874.)——"Cerebral Power in Man." Brown-Séquard, *Lond. Med. Rec.* No. 79.——"Hypnotism in Crustacea." J. Czermak, *Sitzung. d. Wiener Akadem.* LXVI. Heft. 3, 4 & 5. *Lond. Med. Rec.* No. 80, 1874.——"On the Physiology of the Cortex Cerebri." J. J. Putnam, *Lond. Med. Rec.* No. 86.——"Experiments on the Brain." *Lancet*, June 27, 1874.——"Localisation of Functions in the Brain." Burdon-Sanderson, *Nature*, July 30, 1874.——"Alterations of the Spinal Cord consecutive to lesions of the Nerves." Hayem, *Gaz. Méd. de Paris*, No. 16.——"On Vaso-dilator Nerves." Goltz and Freusberg, *Pflüg. Arch.* IX. 1874.——"The Spasm-centre ("Krampfcentrum") of the Frog, and its relation to certain drugs." E. Heubel, *Pflüg. Arch.* IX. 261.

Reflex Innervation of the Arteries of the Pia Mater.—F. Krauspe, *Virchow's Arch.* 1874, LIX. 472 (*Abstract in Centralblatt*, No. 25, 1874). Riegel and Jolly were unable to confirm the assertion of Nothnagel that stimulation of sensory nerves caused reflexly a contraction of the vessels of the pia mater. K. believes that in the case of R. and J. the substances employed to narcotise the animals operated on influenced the activity of the vaso-motor nerve centre,—so that a normal transference of a physiological reflex act may be doubtful. Curare has not this disadvantage. The author's experiments upon rabbits confirm the statement of R. and J. that the vessels of the pia mater do not contract upon a stimulus being applied to peripheral sensory nerves. After an experiment upon a tracheotomised rabbit (to which no curare had been given) had shown that this poison had no effect on the vaso-motor channels, it was tried to investigate the central circulation without trepanning, and with the exclusion of air, viz. by ophthalmoscopic examination of the retinal vessels. The occurrence of a strong and continual flow of tears rendered every attempt at examination fruitless. Lastly the experiments with trepanning and the setting in of a piece of glass in the skull seemed to be useless, in that the action of the air caused inflammation (reflex paralysis of the vessels). Even though the results of two experiments were positive, still the author has arrived at no decided opinion, possibly he thinks the difference in the results may be due to the time of the year in as far as winter animals (Nothnagel experimented on rabbits) are less predisposed to reflex, and on the other hand are more torpid towards inflammatory stimuli.

Removal of the First Thoracic Ganglion of the Great Sympathetic in the Dog.—Carville and Rochefontaine (*Gaz. Méd. de Paris*, 1874. No. 12), by a new method of operation, a description of which is given in the original, were enabled to remove the first thoracic ganglion without injury to the pleura; and in consequence never observed pleuritis, as is common by the other methods of operation, and as said by some to depend upon the extirpation of said ganglion. On the contrary neither increase of the temperature of the ear, nor of the fore foot on the side operated on, were missed, also the oculo-pupillary phenomena and the vascularisation of the conjunctiva as occurs after section of the sympathetic in the neck. Rotatory movements were absent.

INFLUENCE OF EXTIRPATION OF THE SUPERIOR CERVICAL GANGLION ON THE MOVEMENTS OF THE IRIS.—A. Vulpian, *Arch. de phys. norm. et patholog.* 1874. After extirpating the superior cervical ganglion in a dog it was curarised after the course of from 10 to 15 days. Artificial respiration was kept up and the skin of the abdomen and hinder extremities were stimulated with strong induced currents; each time both the pupils became dilated, even that corresponding to the side operated on, and which is innervated from the upper cervical ganglion (a part of the sympathetic was destroyed at the time of extirpation). The iridomotor fibres of the sympathetic must therefore run in other channels, whether along the vertebral artery, or one derived from the cranial nerves, remains to be decided.

PHYSIOLOGY OF VASO-DILATOR NERVES.—A. Vulpian (*Arch. de phys.* 1874. No. 1, 175) contradicts the assertion that there exists a veritable antagonism between the vaso-inhibitory and vaso-motor nerves. Under this assumption the vessels of the corresponding half of the tongue must contract after section of one chorda tympani. This however is not the case. Secondly, in that after section of the chorda tympani widening of the vessels in the mucous membrane of the mouth can be produced reflexly, then the inhibitory nerves of the blood-vessels of the buccal mucous membrane must either run in other channels than through the chorda tympani, or there must be ganglion cells intercalated in the fibres of the latter peripheral to the place of section. Thirdly, after section of the cervical sympathetic and upper cervical ganglion stimulation of the chorda tympani acts with unchanged results. This refutes the hypothesis that by stimulation of the vaso-inhibitory nerves, nothing more than an inhibition of the vaso-motor influence is produced. Or, still above the upper cervical ganglion, centres must be intercalated in the course of the chorda tympani. Fourthly, after section of the upper sympathetic cervical ganglion the histological structure of the chorda remains unchanged.

HYPERTROPHY OF THE EAR AFTER EXCISION OF A PORTION OF THE CERVICAL SYMPATHETIC IN RABBIT.—A Bidder (*Centralblatt für Chirurgie*, No. 7, 1874) excised a piece (1·5cm. in length) of the left cervical sympathetic from a half-grown rabbit. This was followed by the usual symptoms of this operation. In about a month the rabbit had grown just as the other rabbits, and appeared quite sound. The left pupil was only half as large as the right, and the left eyeball projected much less from the orbital cavity than the right. The left ear was distinctly broader and longer than the right, and was more hyperaemic and warmer. A fortnight later the difference in size was more striking. The author attributes the increase in the size of the ear to the increased continued supply of blood to the ear of the young animal where all the nutritive processes are going on actively.

STIMULATION OF THE NERVI SPLANCHNICI.—Van Braam-Hougkeest, *Pflüg. Arch.* VIII. 163 (*Centralblatt*, No. 42), again opens the question whether the inhibitory influence of the nervi splanchnici exists apart from their vaso-motor action or is a consequence of it. He decides for the former. The method of Sanders was adopted, the animal being placed in solution of salt at blood heat, though the preparation and stimulation of the splanchnici were conducted outside the fluid. When both splanchnici were divided, and one of them slightly stimulated the movements of the stomach and intestines previously produced by stimulation of the vagus, ceased at once, without the portions of intestine which were brought to rest becoming pale. In these experiments the strength of the stimulation was sufficient to excite the inhibitory but not the vaso-motor fibres of the splanchnicus.

DITTMAR ON THE VASO-MOTOR CENTRE IN THE MEDULLA.—Owsjannikow placed the under limit of the vaso-motor area in the rabbit, about 4 millimètres (·15 inch) from the calamus scriptorius, the upper limit 4 millimètres higher, 1·2 millimètres below the corpora quadrigemina. C. Dittmar (*Ludwig's Arbeiten* VIII. 103, 1874, and *Lond. Med. Recd.* Vol. II. No. 61, 1874), in order to avoid the uncertainty of making the sections of the medulla with the free hand, as performed by Owsjannikow, has invented an apparatus for holding a small knife, which can be moved in any direction, and for any distance, by means of a finely graduated screw. He also laid the spinal canal more freely open, in order to avoid the accumulation of blood in the sac of the dura mater, as this has been shown to prevent a reflex action from reaching the vaso-motor nerves. Any bleeding from the bone was easily arrested by the application of small pieces of paper which had been dipped in tincture of iron and then dried. The blood-pressure was measured in the carotid.

The author confirms in the main the results of Owsjannikow, and finds that in the rabbit the lower limit of the vaso-motor area lies about 3 millimètres above the point of the calamus scriptorius, 1 to 1½ millimètres (·04 to ·06 inch) below the lower margin of the tuberculum laterale. The upper limit lies in the neighbourhood of the fovea anterior, about the upper margin of the corpus trapezoides. Following the indications given by the experiments of Miescher and Nawrocki, the author found that sections of the anterior and posterior columns, as well as the gray substance of the same, within the third cervical vertebra, did not alter the reflex increase of blood-pressure on stimulation of the sciatic nerve. It, therefore, follows that not only the centripetal fibres (Nawrocki) of the sciatic nerve whose stimulation produces the reflex contractions of the vessels, but also the vaso-motor nerves, run in the lateral columns of the spinal cord. The remainder of the anterior column, pyramids (lying towards the middle line), and the posterior part of the remainder of the lateral column, can be destroyed without materially influencing the reflex vaso-motor activity. There only remains, therefore, on each side, a small prismatic space within the vaso-motor area, whose injury disturbs or causes cessation of the vaso-motor reflex. It forms the anterior part of the lateral column.

Have all the Vaso-motor Nerves their deep origin in the Medulla Oblongata?—A. Vulpian, *Comptes rendus*, LXXVIII., No. 7, 472 (Abst. in *Centralblatt*, No. 44), from his experiments is led to the conclusion that the assumption of a vaso-motor centre which is situated solely in the med. oblongata, is incorrect.

In a curarised mammal in which artificial respiration is kept up, if the spinal cord is divided at the level of the second cervical vertebra, and lower down in the dorsal region the cord be half divided, the temperature rises somewhat in both hind extremities, and in a frog the vessels of the interdigital membrane of the operated side were wider than those of the other side. The vessels of the hind extremity become still wider when in a mammal after transverse division of the cord the nervus ischiadicus of one side is divided, yet the temperature of one ear rises temporarily after division of one cervical sympathetic, even *after* previous section of the cervical spinal cord.

If the vaso-motor centrum was confined to the medulla oblongata, then after section of the cord below the medulla oblongata no reflex phenomena should be exhibited by the vessels. If however one nervus ischiadicus was divided in a curarised dog, on stimulation of the central end of the nerve by the induced current there occurred a diminution of the temperature of this extremity, in comparison with the anterior, about 0·3°C. (Thermo-electric expt.) In a similar manner the author proves that *widening* of the vessels takes place reflexly after division of the cord and separation of the medulla oblongata, as well by experiments on animals, as after observations of reflex redness produced in paraplegic men. The vaso-motor nerves therefore have numerous centra distributed throughout the gray substance of the cord, each one of which can be excited independently. Also in *Gazette Méd. de Paris*, No. 10. (Compare Goltz on *Vaso-dilator Nerves*, *Pflüg. Arch.* IX. 174; Abst. in *Centralblatt*, 1874, 645.)

The Influence of Anæsthetics on the Vaso-motor Centres.—Bowditch and Minot (*Boston Med. and Surg. Journ.* May, 1874) investigated this subject chiefly on curarised dogs. They regard their paper as merely a preliminary one. A series of kymographic tracings are appended. The following conclusion they regard as possessing, at most, a high degree of probability.

I. Chloroform inhalation lowers the reflex irritability of the vaso-motor centres, thus diminishing the power of an irritation of sensitive nerves to cause a rise of blood-tension.

II. Ether acts, if it acts at all, much less powerfully in this respect than chloroform. Ether and chloroform are both anæsthetics, but chloroform is also something more.

. ON THE VASO-MOTOR SYSTEM.—Nawalichin (*Pflüg. Arch.* VIII. 609) has investigated the point whether the vaso-motor phenomena occur simultaneously, and with relatively equal strength in all parts of the arterial system. Simultaneous measurements of the blood-pressure were made in peripheral portions of two arteries; in the case cited, the carotid and femoral. Curarised dogs and cats were employed. The vaso-motor phenomena were produced either reflexly or directly by stimulation of the vaso-motor centre. The reflex effects were produced either from the vagus or sciatic nerves. Direct stimulation of the nerve centre was produced either by diminishing its supply of blood (compression of both carotids), or by disturbed arterialisation of the blood (interruption of the respiration). The following were the results:

1. Central stimulation of the vagus generally produces a pronounced change in the blood-pressure in the peripheral portion of the carotid, which consists in an increase or diminution, without there being a corresponding change of the pressure in the peripheral end of the femoral artery. It sometimes happens that during the increase of blood-pressure in the carotid the pressure in the femoral sinks.
2. Central stimulation of the sciatic nerve causes in the majority of cases an increase of pressure in the carotid, but not in the femoral. Cases occur where the pressure in the femoral also rises, but the maximum occurs later than in the carotid.
3. Occlusion of both carotids (in cats) causes an increase of pressure, sometimes in the one system, sometimes in the other.
4. Interruption of the respiration increases the blood-pressure in both systems, the increase however begins sooner in the femoral, increases equally and lasts longer, so that the maximum pressure in this vessel is absolutely and relatively greater than in the carotid.

The above facts show that the changes in the different vessels caused by the vaso-motor system are not only unequal with different forms of stimulation of the centre, but that they are also not simultaneous with the same mode of stimulation, and that these changes may be of different values, and may even run in opposite directions. This is true not only of different animals, but also of one and the same animal, at different times.

ON THE RESPIRATORY CENTRE.—Gierke, *Pflüg. Arch.* VIII. 583 (Abstr. *Lond. Med. Rec.* No. 71) locates the respiratory centre in a longitudinal bundle of fine nerve-fibres, lying on each side of the middle line in the medulla oblongata. It has previously been described as belonging to the origin of the vagus and glosso-pharyngeal nerves. It is a continuation of bundles, which, higher up in the medulla, pass out transversely from the nuclei of the vagus and hypoglossal nerves, then proceed longitudinally downwards, and lose themselves in the reticular nervous tissue between the anterior and posterior horns. This respiratory centre does not consist of a distinct group of cells. The author regards respiration as a reflex act, the afferent nerves being the trigeminus and vagus, and the efferent nerves the phrenic, intercostals and other nerves. P. Rokitansky

Stricker's Med. Jahrbüch. 1874, 30) considers that the respiratory centre is not confined to the medulla, but extends to the cord; for he finds the respiratory movements occur in rabbits poisoned by Strychnia, although the medulla has been separated from the cord. Rabbits die from imperfect respiration when the medulla is divided at the posterior border of the pons Varolii. When respiration has been arrested by dividing the medulla at this point, it begins again if strychnia be injected.

ON COUGHING.—Koht, *Virch. Arch.* LX. 191 (*Lond. Med. Rec.* No. 80), for his experiments used cats and dogs, which were in no case narcotised. Neither the position of the glottis nor diaphragm were directly observed; the author, like Nothnagel, drawing his conclusions from the occurrence or non-occurrence of the characteristic detonations during coughing. For the production of coughing mechanical (pinching, teasing, tickling with feathers); chemical irritants (common salt and ammonia); thermal (ice); and electrical stimuli were employed. By stimulation of the centripetal fibres of the vagus, reflex coughs are produced, this is proved experimentally:

1. For the trunk of the pharyngeal and superior laryngeal nerves of the pneumogastric.

2. For the peripheral endings of the vagus in the following areas. Coughing occurred:

(*a*) On stimulation of the mucous membrane of pharynx, of the larynx (of the fossa inter arytaenoidea, of the plica glosso-epiglottica, and plicae ary-epiglotticae), of the trachea, of the bifurcation of the trachea, of the bronchi.

(*b*) On stimulation of the costal pleura.

(*c*) On stimulation of the œsophagus (the experimental proof for a so-called stomach-cough is wanting).

(*d*) There is a central cough which can be produced by direct stimulation of the medulla oblongata (*vagus*).

General Physiology of Nerve.

"On Electrotonus and the Inner Mechanics of Nerves." J. Bernstein, *Pflüg. Arch.* VIII. 40.——"Experimental and Critical on Electrotomus." L. Hermann, *Ebenda,* 258.——"On Electrotonus." J. Bernstein, *Ebenda,* 498 (Abstract in *Centralblatt,* No. 29, 1874).——"On the Transformations in the Terminations of Nerves in the Muscles of the Frog after Section of the Nerves." A. Sokolow, *Arch. de Phys. Norm. et Patholog.* 1874, 2 and 3, 300.——"Action of Oxygen on Increased Reflex Excitability." Ananoff, *Centralblatt,* No. 27, 1874.——"Lectures on Electro-Therapeutics." G. V. Poore, *Lancet,* 1874.——"Persistence of Sensibility in the Peripheral Ends of Cut Nerves." Arloing and Tripier, *Acad. Franc.* May 25th (Abstract in *Lond. Med. Rec.* No. 76, 1874).——"Electrical Contributions." Runge, *Deutsch. Arch. Klin. Med.* 1874, XIII. 345.

EFFECT OF TEMPERATURE AND DIFFERENT DEGREES OF THE STIMULATING CURRENT ON THE RAPIDITY OF PROPAGATION OF EXCITATION

IN THE FROG'S NERVE.—A. Trõitzky (*Pflüg. Arch.* VIII. 599). After mentioning the method he adopted for marking with accuracy the distance in a horizontal line between the beginning of two curves on the cylinder of the myograph; the author states his conclusions: 1. With slight intensity of the stimulating current the rapidity of the propagation of stimulation in the nerve is at its maximum between + 20°, and + 10° C. The rapidity diminishes when the nerve is warmed to 30° C, or cooled to 0°. 2. With stronger currents, the influence of temperature on the rapidity of propagations in the nerves diminishes. The rapidity is more influenced by the strength of the stimulating current than by the temperature. 3. With very strong currents the influence of temperature disappears completely. 4. The greatness of the rapidity of propagation in nerves depends upon the strength of the stimulation, and stands in direct proportion to the same.

JUNCTION OF SENSORY AND MOTOR NERVES.—Vulpian (*Arch. de Phys.* 1873, 597, *Comptes rendus,* 1874, No. 4. Abstract in *Centralblatt,* No. 19, 1874, and *Lond. Med. Rec.* No. 77) concludes from his experiments on the union of the divided end of the hypoglossal with the lingual that "the question of the identity of physiological property in all nerve-fibres remains a disputed one, and it is difficult to foresee in which way it will be decided."

Eye.

"Crossing of the Optic Nerves and Hemiopia." E. Mandelstamm, *v. Gräfe's Archiv.* XIX. 2. 39.——"Structure of the Chiasma Nervorum Opticorum." Michel, *Ebenda,* 59.——"Researches on the Communications of the Retina with the Encephalon." Brown-Séquard, *Arch. de Physiol.* 1872, 261 (Abstract of all three *Centralblatt,* Nos. 26 and 27, 1874).——"Doctrine of the Sense of Sight." E. Hering, *Wiener. Acad. Sitzungsb.* LVI. Abth. 3, p. 5 (Abstract in *Centralblatt,* No. 31, 1874).——"On the Estimation of the Point of Intersection of Rays of Light falling excentrically on the Eye." *v. Gräfe's Arch.* XIX. ii. 301 (Abstract in *Centralblatt,* No. 31, 1874).——"Apparent Accommodation in Aphakia." *Onderzoekingen gedaan in het. Labor. Utrecht,* II. 125 (Abstract in *Centralblatt,* No. 32, 1874).——"Zöllner's Pseudoscopic Figure." Guye, *Maandblad voor Naturwetens,* 1873, No. 6 (Abstract in *Centralblatt,* No. 32, 1874).——"Stereoscopic Vision." Van der Meulen and Dooremaal, *Onderzoek. gedaan in het. Laborat. Utrecht.* II. 81 and 119 (Abstract in *Centralblatt,* No. 33, 1874).——"Apparatus for the Demonstration of Listing's Law," described under the name of "Blemmatrope." L. Hermann, *Pflüg. Arch.* VIII. 305.——"On the Posterior limiting Membrane of the Human Iris." A. Grunhagen, *Schultze's Arch.* IX. 726——"On the Theory of Colour-blindness." A. Fick, *Würzb. Verhandl.* B[d]. II. 129.——"On the Measure of the Sensations, and specially of the Sensations of Light and Fatigue." J. Delbœuf, *Mém. de l'Acad. de Belgique,* 8, XXIII. p. 115 (Abstract in *Centralblatt,* No. 35, 1874).——"New Ophthalmoscope," Knapp; Gayat "on the Measurement of the Orbit," Abstracts in *Lond. Med. Rec.* No. 66, 1874.——"Physiology of the Secretion of Tears." M. Reich, *Arch. f. Ophthal.* XIX. Pt. 3. 38 (Abstract in *Lond. Med. Rec.* No. 71, 1874).——"Innervation of the Plexus Chorioides inferior." Benedikt, *Virch. Arch.* LIX. 395 (Abstract in *Lond. Med. Rec.* No. 85). "The Doctrine of the Field of Vision, and its Anomalies." W. Schön (a physiological and clinical study), *Berlin, Hirschwald.* 1874, 8vo. 150 pp. 12 plates and 17 wood-cuts (Abstract in *Centralblatt,* No. 43).

Ear.

"Helmholtz's Model of the Ear, with a Contribution to the Physiology of the Auditory Apparatus." A. Lucæ, *Arch. f. Ohrenheilk.* I. 4.——"Development of the Tympanum." V. Urbantschitsch, *Wiener. Acad. Sitzb.* III. Abth. LXVIII. 1873, 19.——"Tympanum in the Fœtus and the Newly Born." H. Wendt, *Arch. f. Heilkunde,* 1874, XIV. (Abstract of both papers, *Centralblatt,* No. 34, 1874).——"Resonant Functions of the External Ear." *Philadelph. Med. Times,* April 4, 1874 (Abstract in *Lond. Med. Rec.* No. 71).——"Physiology and Pathology of the Eustachian Tube." S. Moos, 8. 58 pp. 7 plates, *Wiesbaden,* 1874 (Abstract in *Centralblatt,* No. 42).——"On the Disturbances of Motion, which occur after Section of Semi-circular Canals." Löwenberg, *Arch. f. Augen. and Ohrenheilk.* III. Abth. 1, 1873, 1.——"Physical Experiments on the Sense of Equilibrium in Man." E. Mach, *Wiener. Acad. Sitzungsb.* LXIII. iii. 1873, 124 (Abstract of both papers in *Centralblatt,* No. 43).

Skin.

THE CONDUCTION OF HEAT BY THE SKIN.—Klug (*Zeitsch. für Biolog.* x. Heft 1, 1874; *Lancet,* Sept. 1874). Senamont showed that the conduction of heat by crystals was, except in those of the regular system, not the same in all directions. De la Rive and De Candolle observed a similar difference in the conductibility for heat of different kinds of wood, the undulations of heat being propagated best in the direction of the length of the fibres, and worst at right angles to them. Griess made experiments on many other parts of plants (the leaves) and then proceeded to investigate animal structures, as the stomach and claws of animals, and in all instances found that wax spread on the tissues round a wire thrust through both wax and tissue, melted in the form of an ellipse when the wire was warmed. Klug has repeated those researches and has investigated particularly the human skin. Instead of wax, however, he uses the more easily *melted* cacao butter, mixed with a little oil. The piece of skin was equally stretched and a brass wire passed through it. The skin of the anterior part of the forearm, and to a somewhat less degree the skin of the back part of the forearm, gave the best marked elliptical figures, though by no means equalling those of wood. The direction of the long axis varied considerably in different cases, so that no general rule could be laid down. The skin of the chest and front part of the thigh furnished a much less elliptical isothermal curve, and that of the back and belly was nearly circular. That of the palm of the hand was perfectly circular. Experiments made with the epidermis and corium of the above parts, separately, shewed that the epidermis conducted heat equally well in all directions, the line of melting of the wax was therefore circular. The corium behaved in this respect like the skin as a whole.

Helmholtz's researches showed that 77·5 per cent. of the whole heat eliminated by the body passes off by the skin, the question therefore arose, what influence the different layers of skin exert on the transmission of heat? The amount of heat given off from the skin depends upon the extent of surface, and on the difference between the surface and its environment; and further as the capacity for conduction is inversely as the square root of the distance from the source of heat, the thickness of the skin will also have some influence. The fat as is already known is of immense value in protecting the body from loss of heat, and hence its accumulation over breast and belly; and secondly the epidermis is a singularly bad conductor of heat, which the author attributes to the arrangement of its cells.

Blood and Circulatory System.

"On the changes of the red blood corpuscles by sepsis, and septic infections, with observations on Microcyten." A. Hiller, *Centralblatt*, Nos. 21, 22, 23 and 24.——"Anæsthesia produced in man by injection of chloral into the veins." Oré, *Comptes rendus* 1874, LXXVIII. 575 and 561.——"Structure of the red blood corpuscles," J. Kollmann, *Siebold and Kölliker's Zeitschr. f. wiss. Zoolog.* XXIII, Hft. 3. 462 (Abstr. in *Centralblatt*, No. 25, 1874).——"The physiological action of Sulphate of *Diazobenzol*," M. Jaffé, *Arch. f. exp. Path.* 1874, II. 1 (Abstr. in *Centralblatt*, No. 1874).——"Action of different preparations of Ergot of Rye on the Heart, and a contribution to the more exact knowledge of the irregular movements of the heart," M. J. Rossbach, *Verhandl. d. Würzb. phys. med. Ges.* N. F. VI. 19. (Abstr. in *Centralblatt*, No. 31, 1874).——"The diagnosis of blood-stains." *Lancet*, Augst. 8, 1874. ——"The separation of acids from the alkaline Blood," *Lancet*, July 1874.——"On the bodily temperature, and on the rapidity of the blood during respiration of oxygen and atmospheric air." Naumow and S. Beljaew, *Pflüg. Arch.* VIII. 601 (*Lond. Med. Rec.* No. 69. II. 1874).——"On the Filling of the Lymphatics of the Pericardium." Schumkow, *Pflüg. Arch.* VIII. (Abstr. in *Lond. Med. Rec.* No. 69, 1874).——"On the Sphygmograph," Boileau, *Lond. Med. Rec.* No. 75, 1874.——"Intra-cellular development of Blood Corpuscles in Mammalia." E. Schäfer, *Microscop. Journ.* June (Abst. in *Lond. Med. Rec.* No. 80, 1874).——Action of Chloral on the Blood," Feltz and Ritter, *Comptes rendus*, Aug. 3, 1874 (*Lond. Med. Rec.* No. 86).——"Circulation in the Frog's Lung," Küttner, *Virchow's Arch.* LXI. 21.——"The red colouring Matter of Blood." Béchamp, *Comptes rendus*, LXXVIII. 850.——"Circulation in the Ear of the Rabbit," Moreau, *Gaz. Méd. de Paris*, No. 11.——"Mode of

Action of the Auriculo-ventricular valves," Sée, *Gaz. Méd. de Paris*, No. 13.——"On the rhythmical movements of the venæ cavæ and specially of the Sinus of the vena cava superior," Colin, *Gaz. Méd. de Paris*, No. 19,——and "On the functions of the Auricles of the Heart," No. 23.——"On the Alkalinity of the Blood," Q. Lassar, *Pflüg. Arch.* IX. 44.——"Hæmantography," L. Landois, *ibid.* 65.——"Influence of Stimulation of the Vagus on the contraction of the heart, in the frog," Nuël, *Pflüg. Arch.* IX. 83.——"On the Action of caffein, of extract of flesh, and potash salts on the action of the heart and blood-pressure, H. Aubert and A. Dehn, *ibid.* 115.——"Action of sensory stimulation on the Blood-pressure," R. Heidenham, *Pflüg. Arch.* IX. 250.——"On the physiological Action of the Ergotin of Bonjean, and that of Wigger," H. Köhler, *Virch. Arch.* LX. 384. (Abst. in *Centralblatt*, No. 43).

ON THE DEPENDENCE OF THE ARTERIAL BLOOD-PRESSURE ON THE QUANTITY OF BLOOD. Worm Müller (*Ludwig's Arbeiten*, VIII. 159, Abstract in *Centralblatt f. Chirurgie*, Nos. 8 and 10, and in *Lond. Med. Rec.* No. 77,) has investigated this subject but regards his communication as merely a preliminary one.

The experiments of Goltz made upon frogs (*Virch. Arch.* XXIX. 394 and those of Tappeiner (*Ludwig's Arbeiten* VII. 193) upon rabbits, showed that a considerable quantity of blood can be withdrawn from these animals without influencing in a corresponding degree the rapidity of the blood-current, and the pressure in the large arteries arising from the Aorta.

The Author's experiments were always made upon dogs. He has established the remarkable fact that the vascular system can accommodate very large quantities of blood without there being any marked increase of the normal arterial blood-pressure, which was always measured in the Carotid. More than sixteen per cent. of the body weight of the animal in blood could be injected into the Jugular Vein without (after the termination of the transfusion) the blood-pressure in the beginning of the Aortic system becoming markedly higher than it was in the normal dog before the commencement of the experiment, *i.e.* the quantity of blood that the animal originally had, could be increased to three times its original amount without producing any marked increase in the Arterial blood-pressure. Within certain limits this holds good, if the blood-pressure had been diminished either by section of the spinal cord, or by blood-letting. As soon, during the injection, as the blood-pressure had reached the value noted before the beginning of the experiment, the addition of several quantities of defibrinated blood, did not raise the pressure above the normal. That the blood in spite of the over-filling of the vascular system remained within it and that no important exit of blood or blood-plasma took place through the walls of the vessels, was established by the negative results after very careful *post-mortem* examination. To dispose of the idea of a simple serous exudation, the thoracic duct was opened to observe the out-flow of lymph during and after the injection of the defibrinated blood. The rapidity of the lymph current increased with the quantity of blood added, but a sinking of the blood-pressure with increased quantity of lymph was not observed. A direct proof of the overfilling of the vascular system is given in the effects of blood-lettings in an animal into which blood had been previously transferred. From such an animal quantities of blood, not sufficient to endanger the life of the animal, were withdrawn from the carotid, and from this animal, over-filled as it was with blood, on continuing the blood-lettings until death ensued, and even by pressing the limbs and body of the moribund animal, scarcely ever was the quantity of blood transfused again recovered. The results of the *post-mortem* examination shewed no marked overfilling of the arteries, and only in the veins of the abdomen was there any appreciable overfilling observed. The Author is of opinion that after transfusion, the blood is specially to be found in the capillaries distributed more or less over the whole body. He is further of opinion that the increase in the capacity of the vascular system is accomplished by the help of the capillary networks, of the smallest veins, and the smallest arteries. Very probably throughout the whole body under normal conditions, many capillaries entirely empty or only partially filled exist, which become permeable to the blood-current, after considerable increase of the quantity of blood. A distention of the capillary networks is not a necessary consequence of the overfilling. This occurs, however, under very pronounced filling of the vascular cavities with blood, and as the author believes, at those places and in those organs, such as in the thoracic and abdominal cavities, where the overfilling is most observable.

Even with pronounced filling of the vascular system no change in the capacity of the heart for doing work (*Leistungsfähigkeit*) occurred. The pulse-beats remained with increased percentage of blood, either unchanged both in animals with divided and in those with intact spinal cord, or they were diminished so irregularly that the latter point could only under certain circumstances be brought into account. The lungs were found congested *post mortem*. An increased friction of the blood in the lungs is not alone sufficient to explain the non-increase of the blood-pressure. Neither congestion of the right heart nor of the large veins which open into it were found.

If after transfusion the quantity of blood in the transfused animal was diminished, the paradoxical phenomenon was exhibited that before one half of the blood injected was recovered, the arterial blood-pressure sank much below the *niveau* which it had before the transfusion. By continuing the blood-letting the animal could be brought near to death, even though the quantity of blood which it had, surpassed by several per cents. of its body-weight the original (normal) quantity of blood; in other words animals which had received from one to three times their original quantity of blood were much more sensitive to blood-letting than in the normal condition. Absolutely, transfused animals yield more blood on being bled to death, which is easily explained by the strongly pronounced filling of the vascular system, but relatively they require much larger, perhaps twice as large, or may be still larger quantities of blood (than in the non-transfused condition), in order to preserve the normal blood-pressure, *i.e.* that necessary for life. In an animal which has been bled from both carotids, until nearly dead, even after blood has ceased to flow from the divided arteries, blood again flows from the carotid on dividing the cervical spinal cord (This observation I have repeatedly verified. *Rep.*), and the stream is increased on raising the posterior extremities and pressing on the abdominal and thoracic walls. The author then discusses the upper and lower limits of the physiological filling of the vascular system, and then follows a short chapter on plethora and transfusion.

INJECTION OF AIR INTO THE BLOOD-VESSELS.—Kowalewsky and Wyssotsky (*Pflüg. Arch.* VIII) injected air into the blood-vessels of curarised cats and dogs, artificial respiration having been kept up. 1. A very considerable quantity of air (200 ccm. and more in the dog,) can be injected into the external jugular vein in the direction of the heart without disadvantage, when the injection is not completed at once, only small quantities being introduced at a time. 2. Much smaller quantities (12 ccm. for the cat, 14 or less for the dog) injected at once are sufficient to kill the animal. 3. The effects on the blood-pressure and action of the heart were also noted. *Post-mortem* in animals in which large quantities of air had been injected gradually, either none or very little air was found in the left side of the heart and arteries, but it was found in the right heart and in the pulmonary arteries, though the amount was less than that injected. 4. Large quantities of air injected into the jugular vein in the direction of the heart produce effects in the circulation similar to those of ligature of the inferior vena cava. Death follows, because the blood is prevented from passing from the veins into the arteries in consequence of the formation of considerable quantities of froth in the right side of the heart. The cause of death is an arterial anaemia (notwithstanding that the action of the heart continued for some time). 5. The effects also of injecting the air peripherally, towards the brain, were studied. 6. Experiments with frothy blood (defibrinated blood shaken with air) injected through the pulmonary artery of the excised lungs, showed that the pulmonary and central capillaries do not present any insurmountable resistance to the blood charged with air-bubbles. The hindrance to the blood-current in the capillaries is, if present at all, only temporary. The danger of the entrance of air into the veins does not consist in the formation of capillary emboli in the lungs or brain, but in the production of a considerable quantity of froth in the right heart whereby a mechanical hindrance to the normal circulation and its consequences—anaemia of the aortic system—are produced. (Fuller Abstract in *Lond. Med. Rec.* No. 69, 1874.)

ON THE DEPENDENCE OF THE MEDIUM CURRENT OF BLOOD ON THE DEGREE OF EXCITATION OF THE SYMPATHETIC VASO-MOTOR NERVES.—K. Slavjansky (*Ludwig's Arbeiten*, VIII. and Abst. in *Centralblatt f. Chirurgie*, No. 19, 1874) has made a large number of experiments upon the carotid artery and inferior vena cava of young dogs and rabbits, to ascertain whether the rapidity of the whole blood-current was increased or diminished when a large number of sympathetic and vaso-motor nerves were stimulated simultaneously. Simultaneously with the estimation of the rapidity of the volume of the blood flowing out of the inferior vena cava (for the method by which this was ascertained, vide the wood-cut and description in the original), the blood-pressure was measured in the carotid. The inferior vena cava was operated on because its blood passes through muscles, bones, skin, and the intestines, *i. e.* through organs which stand in the most different relations to the vaso-motor nerves. The results obtained from the vena cava were controlled on the carotid by two series of experiments. The blood caught from the carotid was measured by the apparatus of Tappeiner (*Ludwig's Arbeiten*, 1872), whilst a mercurial manometer was connected with the carotid of the opposite side.

From observations on the spinal cord of curarised dogs the following results were obtained.

1. The quantity of blood which passes through the heart varies with the stimulation of the spinal cord; after division of the spinal cord it sinks below the normal, after stimulation of the same it increases from five or six to ten times.

2. With this increase of the blood flowing through the heart, on stimulation of the spinal cord, *i. e.* of the sympathetic vaso-motor nerves, the pressure in the aortic system also rises, because the contents of one part of the vascular system (inferior vena cava) are driven by the stimulation of the nerves, which cause contraction of the vessels, into the aorta, and so the contents and pressure are here increased.

In order to control the correctness of these results, the vascular area, which was closed, or at least lessened by the stimulation of the sympathetic nerve-fibres, was artificially shut off by ligature of the intestinal arteries and of the portal vein, and on stimulation of the splanchnic nerve the following results were obtained.

1. Ligature of the cœliac, and of the superior and inferior mesenteric arteries, led to obstruction of the aortic current, and therewith obstruction to the flowing off of blood in a wide area. The rapidity of the quantity of blood flowing in the vena cava is somewhat diminished, the pressure in the aortic system increased.

2. Ligature of the portal vein produced widening of current area of the vessels of the abdomen, and filling with blood; the pressure in the aortic system was diminished until death, and there was diminution of the volume of blood flowing.

3. Stimulation of the splanchnic nerve produced closure of the abdominal arteries and emptying of their contents. Pressure in the aortic system was increased, and there was an increase in the volume of blood flowing (*Lond. Med. Rec.* No. 88).

On the Changes of the Heart's Beat upon Reflex Excitation of the Vaso-Motor Nervous System, and Increase of the Intra-Cardial Pressure, and on the Influence of the Cervical Spinal Cord on the Number of Beats of the Heart.—P. Knoll, *Wiener Acad. Sitzungsb.* lxvi. iii., 1872, 56 pp., and *ebenda* 26 pp. (From Abstract in *Centralblatt*, No. 36, 1874).—The observation of Kratschmer's, that, upon stimulation of the nasal mucous membrane with divided n. vagi in the rabbit, irregularities in the beats of the heart occur, forms the outset of the author's investigations. Under the same experimental conditions he observed a rapid and considerable increase of the blood-pressure, which was followed very soon by a slowing of the heart's beats, whilst the pulse-waves written by the kymograph increased in height. Thereby peculiar irregularities shewed themselves in the pulse-curve, in that, the waves characteristic of excitation of the vagus, as also strong, two or three-pointed elevations (pulsus bi- or trigeminus) of the duration of two or three slowed heart-beats, alternated with normal waves, chiefly in an irregular manner. These irregularities went temporarily along with the increased blood-pressure. In these experiments the increase of the blood-pressure depends very probably upon the reflex excitation of the vaso-motor centrum. Phenomena, the same as those just described, can be produced by the stimulation of other peripheral nervous expansions, *e. g.* by stimulation of the conjunctiva, and the increase of pressure never occurred when the spinal cord had been previously divided. In this case the changes in the frequency and rhythm of the heart-beats were absent. When, however, the blood-pressure, lowered by division of the spinal cord, was again increased by elevation of the posterior part of the body or by compression of the aorta, then several times those characteristic irregularities in the pulse-curve occurred on stimulation of the spinal cord, and that without the pulse being slowed. In fact, further experiments shewed that when the blood-pressure had not sunk below a certain minimum, preferably with intact spinal cord, sudden considerable increases in blood-pressure, such as can be produced by compression of the aorta, or stimulation of the splanchnicus, occasion at once irregularities in the rhythm of the heart-beats, even when the heart is freed from all its connections with the central nervous system. With intact spinal cord, increase of the intra-cardial pressure diminishes simultaneously the frequency of the pulse; but the frequency is never thereby influenced when the heart is completely separated from the central nervous system. The opposite assertion of Bezold and the brothers Cyon is questioned by the author. Concerning these irregularities of the action of the heart which are caused by increase of the intra-cardial pressure without the intervention of the parts of the nervous system situated outside the heart, they are, according to the author, to be regarded as the expression of abortive heart-beats, in that, between the single contractions only incomplete diastoles follow; these contractions have small force, and only from time to time single powerful systoles are inserted.

In the second cited communication the author shews that the diminution of the frequency of the heart-beats which occurs after section of the spinal cord in curarised rabbits, in which the cervical nerves (vagi, depressores) have been divided, must be regarded as independent of the simultaneous change of pressure, in opposition to the view of Cyon. Under different circumstances (*e. g.* after stimulation of the central end of the N. depressor after previous section of the vagi, or after inspiration of amyl nitrite) a considerable diminution of the blood-pressure is observed without slowing of the heart-beats. Stimulation of the peripheral end of the spinal cord always gave an increase of the blood-pressure, which was small, but still was present, when the aorta was compressed or the splanchnici were previously divided. Simultaneously an increase of the heart-beats occurred, which lasted long after the blood-pressure had again sunk. The acceleration of the pulse never reached a value surpassing the mean normal frequency. From the above-cited communication it results that increase of the pressure cannot be the cause of acceleration of the pulse; and other observations support this view. How the increase of frequency of the pulse is caused is explained differently by different authors (Bezold, Cyon, Traube). Even the fact, that electrical stimulation of the intact spinal cord, when the cervical nerves are divided, never influences the number of pulse-beats, shews that the view of Bezold of special, spinal motor cardiac nerves is very probably wrong. On the contrary, many facts support the hypothesis that on stimulation of the spinal cord fibres are met with whose excitation diminishes the inhibition of the heart's action; above all, the fact that the influence of stimulation of the vagus can be paralysed by simultaneous stimulation of the spinal cord. Whether the inhibitions of the heart's action are increased after section of the spinal cord, what connection exists between the slowing of the pulse and division of the spinal cord, must be left for the present.

ORIGIN OF ŒDEMA.—Th. Rott (*Berlin. klin. Wochenschr.* 1874, No. 9) confirms the results of Hehns (*Journ. of Anat. and Phys.* VIII. 405), that œdema may arise without section of nerves, when, either by ligature of large venous trunks or numerous veins, the completion of the collateral circulation is hindered. After section of the corresponding nerves more pronounced œdema occurs on account of the increased fluxion. [These facts I have often verified. *Rep.*]

GASES IN HUMAN TRANSUDATIONS.—A. C. Ewald, *Reich. und du Bois Reymond's Arch.* 1873, 663 (1st communication). (Abstract in *Centralblatt*, No. 37, 1874.) The author obtained the fluid to be investigated by means of a trocal provided with an elastic tube, and caught it directly over Hg, in the apparatus of Pfleuger provided with three stop-cocks, a description of which is to be found in the original. By this arrangement the admixture of air was completely excluded. As the pumping out of the gases could be always immediately undertaken, the three-stop-cocked tube was cooled in several experiments with ice-water, in order to avoid decomposition. The results of this method compared with those obtained in the usual way, shewed that this procedure was superfluous. For the analyses pleuritic effusions and transudations in different stages were exclusively employed. Ascitic fluids were avoided because in them there was a possibility of diffusion from the intestinal canal. The author divides the exudations employed into purely serous exudations, which gradually become purulent, "chronic," and acute purulent exudations. To these on the one side belongs the œdemas, on the other the pure pus of abscesses. The quantity of gases in œdematous fluid does not vary greatly from physiological lymph. The loosely bound CO_2 in Case I was 16, 91 vol. per. cent., in II 16, 63; the firmly united in Case I 6, 92, in II 23, 7.—The serous pleuritic exudations shewed an increase of the whole quantity of CO_2, with the duration of the condition; it increased from 33, 84 vol. p.c. to 63, 84 p.c. Only in one case was there an exception, but in this case pneumothorax coexisted, and CO_2 could be removed by diffusion. The more purulent exudations shewed that the value for the CO_2 however, depends upon another factor; the sum of CO_2 contained in an exudation is ceteris paribus smaller, the more its condition approximates to pure pus. The CO_2 is almost exclusively contained in pus-serum—the more this recedes in proportion to the pus-corpuscles, the less must be the value for the CO_2.—Concerning the increase of CO_2 with the duration in the more serous exudations, it is shewn that it is chiefly the firmly bound CO_2, which is first expelled by addition of acids; here there is quite a regular increase. For the explanation of these facts there come into consideration 1. The passage of loosely bound CO_2 into firmly united CO_2 in consequence of the increase of the partial pressure; 2. The addition of CO_2 salts by endosmose; 3. The absorption of watery constituents. In the purulent exudations the quantity of fixed CO_2 sinks continually, until in the pus of an abscess it equals O. There are two ways of explaining these phenomena; increase of the alkalinity and the capability of pus-corpuscles to expel CO_2—as the red blood-corpuscles do. An increase of alkalinity could not be proved, so that there only remains the second possibility, and by special experiments it was, in fact, proved that the pus-corpuscles—pus free of gases—are able, on pumping out, to expel CO_2 from pure simple carbonate of soda, quite in the same way as mineral acids. Small quantities of O and N could be detected in all cases, and the quantity of O and N was under 1, 8 p.c. As the quantity of these two sorts of gas is nearly the same as in blood-serum, and does not increase with the addition of pus-corpuscles in proportion to the serum, it therefore follows that the pus-corpuscles and white blood-corpuscles contain no O or only traces, *i.e.* are not O-carriers like the red ones. H, H_2S, HC_4 were found once, in a putrid exudation.—The reaction of œdematous fluid as well as of the serous exudations was always alkaline, that of pronouncedly purulent exudations as well as of pure pus more or less acid. The specific gravity varied from 1005—1026.

THE RESISTANCE OF THE WALLS OF THE VESSELS IN THE NORMAL AND INFLAMED CONDITION.—F. v. Winiwarter, *Wiener Acad. Sitzb.* III. Abth. B. 3, LXVIII. 1873 (Abstract in *Centralblatt*, No. 30, 1874). In order to compare the capability of resistance in inflamed parts with that in the normal condition, v. W. produced inflammation of the mesentery of the frog by means of cantharides. The animal was injected next day, and always at the same time a sound one for comparison. The injection mass consisted of water, soluble Berlin blue, and gelatine; and the injection was made by means of Hering's apparatus, with constant pressure.

The result of 70 experiments was, that as well in normal as in inflamed mesenterium, injection mass passed through the walls of the vessels, but there was a pronounced difference in as far as the exit of the injection in the inflamed condition occurred oftener and was more copious, and followed even the lowest pressure employed (25 mm. Hg), whilst in the normal condition exit of the mass was only observed in those cases where the pressure had exceeded 70 mm. Similar results were obtained by another series of experiments where the frog pumped the mass into the vessels by the action of its own heart.

The experiments shew that in the inflamed mesenterium exit is occasioned by a vis a tergo, which produces none in the healthy condition, and that a vis a tergo which is capable of producing an exit even in the normal condition, produces in the inflamed more numerous and larger extravasations. If it is concluded that the vessels in the inflamed condition offer less resistance than in the normal, it must not be forgotten that the vis a tergo could be made equal in experiments and counter-experiments, but still the lateral pressure was not equal without and within. In the inflamed tissue, in which the blood-vessels are stuffed full with blood-corpuscles, the injection finds a greater resistance than in the normal vessels, and so in consequence with equal vis a tergo the lateral pressure must be greater.

In fact one can convince himself with the eye that the injection progresses less free and easily in the vessels of the inflamed mesentery than in those of the normal, a condition which the blood must shew in living inflamed vessels. If it is remembered, however, that in the inflamed mesentery, already at 25 mm., the exit of the injection mass was observed, and that in the normal condition this occurred first, when the pressure had exceeded 70 mm., so one must conclude that the walls of the vessels themselves have undergone an essential change by the inflammation, in consequence of which they offer less resistance to the passage of injection mass, red and white corpuscles, than in the normal condition, a result which coincides fully with the latest investigations of Cohnheim.

INFLUENCE OF THE GASEOUS CONTENTS ON THE SOLUBILITY OF THE BLOOD-CORPUSCLES.—L. Landois, *Centralblatt*, No. 27, 1874. If different portions of the same blood are treated with CO_2, O, and nitrous oxyde, the red blood-corpuscles exhibit great varieties with regard to their solubility. The corpuscles charged with CO_2 are dissolved much sooner than the others. Certain re-agents which are unable to dissolve blood charged with other gases produce at once in blood charged with CO_2 the lake colour. The re-agents employed were salts of the bile-acids, very dilute NaCl solution, serum of dog's blood, for the blood of rabbits and guinea-pigs. Nitrous oxyde blood stands between CO_2-blood, and CO-blood. The blood corpuscles of all sorts of blood become, before their solution, round, and shew exceedingly fine points. Perhaps the condition of the hæmoglobin in the cells at the time may account for this.

MICROSCOPIC OBSERVATIONS OF THE FORMATION OF FIBRIN FROM THE RED BLOOD-CORPUSCLES. (*Ibid.*) The formation of fibrin dependent on the solved corpuscles is here described. If a drop of defibrinated rabbit-blood is brought into a drop of frog-serum, the cells aggregate together, become sticky on their surfaces. The cells soon become globular, and those cells lying towards the periphery allow the blood-colouring matter to pass out. This discolouring gradually extends towards the centre of the drop, and at last only a heap of stroma remains. The stroma substance is very tough and viscid. At first the contours of the cells can be detected; when the stroma has been agitated to and fro, the cellular contours disappear and viscous fibres and stripes are observed. Step by step the formation of fibrous masses from the dissolved mammalian cells can be observed. The author thinks this fibrin should be called *stroma fibrin*, in opposition to the ordinary fibrin, or *plasma fibrin*, which is formed without solution of the blood-corpuscles. The two kinds of fibrin may possibly be chemically distinguishable from each other. In transfusion, if dissolution of the cells occurs, then of course the formation of stroma fibrin may take place. The coagulations occur the sooner, the more venous the state of the blood. Animals in a state of asphyxia, in whom heterogeneous blood was introduced, shewed the most extensive coagulations.

MOVEMENTS OF THE HEART.—Vulpian (*Gazette Hebdom. de Méd.* May 8th, 1874) exposed the heart of a curarised dog, and in order to diminish the rapidity of its movements, a quantity of infusion of digitalis was injected into the femoral vein. The conclusions arrived at were: 1. The auricles in mammalia have a very distinct unmistakable systolic movement, which immediately precedes the systolic movement of the ventricles. 2. There can be several contractions of the auricles to one of the ventricles. 3. The revolution of the heart begins with the systole of the auricle, and finishes with the diastole of the ventricle. Also Colin, in *Progrès Médical*, April 25th, and *Lond. Med. Rec.*, No. 72, 1874.——Bouillaud, *Gazette Méd. de Paris*, No. 9.

ON THE DISSOCIATION OF OXY-HÆMOGLOBIN.—Albert Schmidt (*Centralblatt*, No. 46), under Preyer's direction, examined the heart-blood of guinea-pigs and frogs micro-spectroscopically with exclusion of air, and then tested the oxygen-extracting action of different tissues. The following facts were noted.

I. The cardiac blood of *living* fœtal guinea-pigs constantly contains oxy-hæmoglobin before the first respiration.

II. The cardiac blood of grown-up animals contains

a. Much O-hæmoglobin after death by (1) hunger, in warm-blooded animals; (2) freezing, ditto; (3) blowing of air into the jugular veins; (4) poisoning with hydrocyanic acid (frog).

b. Hæmoglobin free of O, and only traces of, or no O-hæmoglobin after death by (1) closure of the trachea and drowning; (2) pneumothorax; (3) puncture in the respiratory centre; (4) blows on the head; (5) respiration of rarefied air; (6) respiration of hot air; (7) freezing in the frog; (8) poisoning with nitrobenzol, chloroform, alcohol, arsenurated hydrogen, iodine, physostigmin, strychnine, quinine, nicotin, potash-saltpetre (frog), soda-saltpetre (frog).

c. At one time O-hæmoglobin is in excess, at another hæmoglobin free of O; or both may be in nearly equal quantities after death by (1) poisoning with arsenious acid, in warm-blooded animals; (2) poisoning with HCN, ditto; (3) injection of steinölin into the jugular vein.

III. Many dissociation experiments made with tissues gave the following: frog-muscles which were tetanised continually, dissociated O-hæmoglobin outside the body (ceteris paribus) quicker than those which had not been active, but not so quick as dead muscles, and the dissociation set in before the change of the spectrum by lactic acid.

Brain and liver withdraw the O from the O-hæmoglobin very rapidly in watery solutions, the latter itself at a temp. of 0°C.

Fungi placed in solutions of blood produced a rapid dissociation and then changes of the spectrum, such as are produced by dilute acids.

Quinine presents the dissociation of O-hæmoglobin by fungi, but not that through brain and liver substance.

Cells containing Blood-corpuscles in the Spleen.—A. Kusnezoff (*Wiener Acad. Sitzber.* 1873, III. Abth. Bd. LXVII. S. 58) has investigated upon the warm stage a large number of spleens from freshly killed mammals, birds, and amphibians, and thereby could ascertain the most various motor processes and phenomena in the so-called "Blutkörperchenhaltigen Zellen." He could repeatedly follow the process in the splenic blood of the rabbit, whereby the colourless cell directly seized the coloured corpuscles and took them into itself. Also within the colourless cell, division of the enclosed coloured corpuscles was seen to take place. The opposite process was also observed, viz. the extrusion of red blood-corpuscles, or parts of the the same, out of the white colourless cells.

From these observations K. concludes: 1. The structures described in the spleen which contain the red blood-corpuscles are really cells. 2. They arise, in that, pulp-cells ("*Pulpazellen*") take to themselves red corpuscles. 3. Within them the destruction of the red corpuscles and their change into pigment occurs. 4. This process is physiological.

Lymph.

On the Dependence of the Secretion of Lymph on the Blood-current.—H. Emminghaus (*Ludwig's Arbeiten*, VIII. 51, 1874, and *Lond. Med. Rec.* Vol. II. No. 58, 1874) has studied the dependence of the secretion of lymph on the blood-current. In this case, the hind foot of the dog was employed, and the lymph-vessels were emptied artificially by the hand. No lymph flowed out generally, when the foot was quiet and at rest, in animals poisoned with opium, a fact already pointed out by Paschutin. [I have been able to verify this fact on non-poisoned animals.—*Rep.*] Section of the vaso-motor nerves produced no diminution in the secretion of lymph. In animals in which the sciatic nerve had been cut through, on ligature of the veins of the limb, the lymph flowed out more richly than before; and when the veins were kept tied, the quantity of lymph was from four to six times greater than before the ligature of the veins. Here swelling of the foot was observed. During ligature of the veins, spontaneous outflow of lymph was often observed. On removal of the ligatures, the after-effect of the stagnation shewed itself in the increased excretion, for an hour or more. Not only did the lymph vary in quantity during ligature of the veins, but also in percentage composition and in colour. In normal experiments the lymph was generally clear; when the veins were tied, the colour became deeper red with the duration of the ligaturing. The percentage composition of the serum (in albumen as in Paschutin's experiments) diminished in fixed constituents in lymph obtained from limbs with the nerves divided and the veins tied. Ligature of the veins without previous section of the nerves increased the formation of lymph, but still only in a moderate degree.

From his experiments, Emminghaus concludes that obstruction to the outflow of blood from the limb is of much greater significance for the excretion of lymph than changes in the strength of the arterial current; and further that, when the limb is so placed that there is no hindrance to the outflow of blood from the veins, little or probably no lymph is secreted. New lymph, however, is formed immediately, either when the elastic equilibrium of the tissues is disturbed, or when any obstruction is offered to the outflow of the venous blood.

Respiratory System and Voice.

"On the Innervation of the Glottis of the Frog." Spiró, *Pflüg. Arch.* VIII. (Abstract in *Lond. Med. Rec.* No. 69, 1874)——"Paralysis of the Dilator of the Glottis." F. Penzoldt, *Deutsch. Arch. f. Klin. Med.* 1874. XIII. 107. (Abst. in *Centralblatt*, No. 30, 1874.)——"Asphyxia through insufficiency of Oxygen." Le Blanc, *Lond. Med. Rec.* No. 73, 1874.——"Cause of the first Inspiratory Act in Infants." H. Lahs, *Archiv f. Gynæcol.* IV. 1873. (Abst. in *Lond. Med. Rec.* No. 72, 1874.)——"Combustion in the Animal Organism." Schützenberger, *Lond. Med. Rec.* No. 85.——"Physiology of the Human Voice." Kilian, *Pflüg. Arch.* IX. 244.

EXTENSIVE CAPILLARY EXTRAVASATION OF BRIGHT RED BLOOD INTO THE PULMONARY TISSUE OF THE INSANE."—Dr Jehn (*Centralblatt*, No. 22) refers to Nothnagel's results upon hæmorrhage into the lungs coincident with injury to the brain (*Journ. of Anat. and Phys.* VIII. 397), and cites 5 cases of his own (1 case Melancholia, 1 Mania, 3 Paralysis), where in the lungs extravasations of bright red blood, completely resembling arterial blood, were found. The patches were sometimes distributed, and in one case the extravasation was almost total. The boundaries were irregular but sharp, the bronchi were free. Microscopically, the alveoli were almost exclusively filled with red blood-corpuscles. No changes were to be observed in the vessels and pulmonary tissue. The pathological results in the nervous system were partly negative, partly old and fresh meningitic new-formations, hæmorrhagic pachymeningitis diffuse redding of single gyri, in two cases apoplexy of the gray matter of a capillary nature. During life no manifestation of the lung affection was exhibited.—See also the *Lond. Med. Rec.* No. 74, 1874, for a series of cases, with remarks taken from the *Progrès Medical.*

Action of Vapours when applied to the parts of the Trachea below the Larynx.—Ph. Knoll, *Wiener Acad. Sitzungsb.* LXVIII. III. (Abst. in *Centralblatt,* No. 44), shews that in rabbits by stimulation of the respiratory passages below the larynx, *i.e.* in the area of the terminations of the vagus, the respiratory movements are changed characteristically. These movements were recorded graphically, in that the variations of pressure of the enclosed volume of air in which the animal to be experimented upon was placed, produced by the movements of the thorax, were communicated to a Marey's cardiograph. The animal respired through a tracheal canula, which communicated by an india-rubber tube with the atmosphere, *i.e.* with the stimulating substance to be investigated. The inspiration of chloroform, weak ammonia solution, and several other vaporous stuffs, produced an acceleration and flattening of the respiratory movements with a deep position of the diaphragm, together with inspiratory tetanus through the Nv. vagi. Slowing and deepening of the respiratory movements, together with expiratory tetanus through the vagi, were produced by the inspiration of strong solutions of ammonia. Still, this excitation of the expiratory vagus fibres is followed in the greatest number of cases by an excitation of the inspiratory fibres, *i.e.* by flattening and acceleration of the respiration. The author therefore holds as proved the results of previous experimenters, who observed expiratory tetanus of the diaphragm after stimulation of the central end of the vagus. Apnœa was not importantly affected by the inblowing of chloroform, &c. After the disappearance of these the action of the stimuli blown into the lungs was manifested at once. Carbonic acid does not stimulate the peripheral ends of the inspiratory fibres of the vagus, as Berut maintains. First, several minutes after the inspiration of this gas peculiar changes in the respiratory movements occur; the CO_2 appears to act rather on the central origins of the respiratory muscle-nerves, after its absorption into the circulation.

Alimentation.

"A Treatise on Food and Dietetics." F. W. Pavy, M.D.; J. & A. Churchill. ——"On some points in the Dietetic Treatment of Disease." E. A. Parkes, *Lancet,* May, 1874.——"On the Nerves of the Digestive Canal." Arnstein, *Pflüg. Arch.* VIII. (Abstract in *Lond. Med. Rec.*

No. 69, 1874.)——"Physiological Action of Alcohol." Dogiel, *Pflüg. Arch.* VIII. Heft 11 & 12. (Abst. in *Lond. Med. Rec.* No. 69, 1874.)——"On Casein and Albumin." Béchamp, *Lond. Med. Rec.* No. 80.——"Intestinal Digestion." G. M. Garland, Supplement to the *Boston Med. and Surg. Jour.*——"On the Pyloric Glands." Ebstein and Grützner, *Pflüg. Arch.* VIII. 617.——"Question of the Estimation of Nitrogen in Albuminous Bodies." Seegen and Nowak, *Pflüg. Arch.* IX. 227.——"On the Digestion of Alimentary Substances." Leven, *Gaz. Méd. de Paris*, No. 9.——"On the free Acid of the Gastric Juice." J. V. Laborde, *Gaz. Méd. de Paris*, Nos. 32, 33, and 34.——"On the Nutrition of Animal Tissues." Marcet, *Lond. Med. Rec.* No. 88. II.——"Colour Reaction of Albumen." A. Adamkiewicz, *Pflüg. Arch.* IX. 156.——"On Peptones and Nutrition with the same." P. Plósz, *Pflüg. Arch.* IX. 325.

FORMATION OF FAT IN THE ANIMAL BODY.—H. Weiske and E. Wildt, *Zeitsch. f. Biologie*, 1874, x. 1. (Abst. in *Centralblatt*, No. 43.) Voit and Pettenkofer have shewn that in the dog the body fat arises from the albumen taken in the food, and even when this is free from fat the carbo-hydrates take no part in the formation of fat. The above authors treat the same question in herbivora, *i.e.* omnivora. Two swine of from 3—6 weeks old were killed, and the proportion of fat of the whole body estimated, whilst another was fed for half a year on starch and potatoes. The food was weighed exactly each time, and often analysed; the fæces were collected, and by their analysis it was ascertained how much food had been absorbed. It was shewn that the food was almost completely digested. We can only cite the results. The "potatoe-sow" contained at the end of the experiment 2,2835 kilo. albumen, 7,0138 kilo. fat, 0,4101 substances free from albumen. The control-animal, which at the beginning of the experiment may be regarded as of the same composition as the animal experimented on, contained 1,014 kilo. albumen, 0,874 kilo. fat, 0,0843 kilo. substances free from N. There was thus formed during the feeding 1,2425 kilo. albumen, 6,1398 kilo. fat, 0,3258 kilo. substances free from N. 0,5748 kilo. fat were taken with the food. If we assume that this was directly absorbed, then 5,565 kilo. fat have been formed in the body. The albumen taken in was 14,3244 kilo., of this 1,2425 kilo. were stored up, so that 13,0819 kilo. remain disposable for the formation of fat. According to Henneberg this could yield 6,7241 kilo. fat. Thus even with food very poor in albumen, the albumen taken in would suffice to explain the formation of fat, though of course that the carbo-hydrates might have aided in the formation of fat, is not excluded.

ON THE CAUSE OF THE HIGH SECRETING PRESSURE IN THE GLAND. SUB-MAXILLARIS.—E. Hering, *Wiener Sitzber.* 1872. Abth. III. Bd. II. (From Abstract in *Centralblatt*, No. 35, 1874.) In the cells of the sub-maxillary glands during their physiological state of activity, according to the hypothesis of the author (and others), a colloid substance is produced, which by its considerable endosmotic equivalent explains the high secreting pressure in these glands. This colloid substance is probably mucin. The great rapidity with which the saliva is secreted after stimulation of the glandular nerves, only seemingly speaks against this. The mucin formed in the gland-cells is separated by a thin membrane from the fluid which causes it to swell up, and as mucin is always formed anew from the numerous cells, new quantities of a watery fluid can always be attracted. The saliva so formed is secreted with stoppage in salivary ducts, towards which the gland-cells are not separated by any membrane. Not with more difficulty than the rapidity can the high pressure of the secretion be explained from the enormous forces which come into play in imbibition.——"Reflex Secretion of Saliva." Nawrocky, *Pflüg. Arch.* VIII. 601 (Abstract in *Lond. Med. Rec.* No. 69, II. 74).

ON A NEW METHOD OF ESTIMATING THE QUANTITY OF PEPSIN BY THE COLOUR.—P. Grützner, *Pflüg. Arch.* VIII. 452 (Abstract in *Centralblatt*, No. 20, 1874). Fibrin is to be coloured by placing it in a solution of carmine, immediately to preserve it in glycerine, and before making an experiment after washing away the glycerine place it in dilute HCl (0·2 p.c.) until it swells up. By this means a beautiful red-coloured jelly-like mass is obtained, which is easily dissolved in digesting fluid, and just in the degree to which it dissolves is it coloured red. The greater the quantity of pepsin in the fluid to be investigated, the quicker does the solution of fibrin take place (cæteris paribus), and therewith the red colouring of the fluid. This method is as well fitted for the detection of small quantities of pepsin, as for the comparison of the quantity of pepsin in two fluids.

DIGESTIVE FLUID IN THE FŒTUS.—A. Moriggia, *Revista Clinica*, 1873, S. A. 38. 8°. (Abstract in *Centralblatt*, No. 22, 1874). The author has investigated more than 100 embryos (chiefly of the cow) from the most different periods of development, and has found that the digestive power of the mucous membrane of the stomach is present, and can be demonstrated, not only in the sixth and fifth, but also in the fourth and third month of pregnancy. The salivary glands, on the contrary, have no digestive properties either in the fœtus or in the newly-born (compare Schiffer and Korowin, *Journ. of Anat. and Phys.* VIII. 206). The gall-forming function of the liver begins very soon. When the liver begins to produce glycogen, could not be accurately ascertained, for even at the earliest period of development of the liver, almost all the embryonal tissues contain glycogen or glycose. Embryos which had been preserved for a long time at the temperature of the body, in Moleschott's acetic acid mixture, were by the action of their own gastric juice completely digested without a trace being left over. To self-digestion the author seeks to ascribe the disappearance of dead embryos in closed cysts. The parts of such embryos which generally remain to the last are either those which are widely removed from the stomach (*e.g.* head), or those which afford resistance to the digestive power of the gastric juice (*e.g.* hair, bones). From the constant presence of amniotic fluid in the stomach, and of amniotic epithelum in the meconium of the embryos of the cow, it is to be concluded with certainty that a constant swallowing of the amniotic fluid takes place in the embryo.

Once more the Pyloric Glands.—v. Wittich, *Pflüg. Arch.* VIII. 444. (From Salkowski's report in *Centralblatt*, No. 25, 1874.) The author confirms the results of Ebstein and Grützner, that extraction with HCl from the pyloric glands yields pepsin (*Journ. of Anat. and Phys.* VIII. 207), whilst in glycerine this does not pass over; but differs from these authors in the explanation of the result. He supposes that the protoplasm of the epithelium of the pyloric glands in coagulation absorbs pepsin, just as coagulated fibrin does, and that this coagulation is accelerated by the action of water. The author refers to the analogy in the properties of white of egg; if a concentrated solution of this is dropped into water, the formation of membranous precipitates is observed, which are not formed when weak solution of Na Cl (0·5—1 per cent.) instead of water is employed; by the addition of Na Cl solution such a precipitate once formed can be caused to disappear. When carefully washed out, these precipitates are able to take up pepsin from pepsin-glycerine, so that the glycerine becomes inactive, while the flocculi, by virtue of their pepsin, readily dissolve in 0·2 per cent HCl solution. If the albuminous flakes laden with pepsin are digested in glycerine, they yield no pepsin, but do so when they are digested with a mixture of equal parts of glycerine and one per cent. solution of Na Cl. The washing out of the mucous membrane of the pylorus may lead to the coagulation of the protoplasm of the cells and fixation of the dissolved pepsin. The circumstance that the mucous membrane of the fundus yields pepsin to glycerine, is explained by the author in the following way. A distinct quantity of fibrin can only absorb a distinct and that a small quantity of pepsin, so that it is difficult in this way to free a somewhat concentrated pepsin solution from its contents in pepsin. The coagulated protoplasm and the glandular cells of the mucous membrane of the fundus would fix pepsin, but far from all, as the quantity of pepsin in the pyloric mucous membrane is much greater. Thus is explained the observation that mucous membrane exhausted by glycerine yields new pepsin in dilute HCl, and why active extracts are obtained from the pyloric mucous membrane, whilst this does not succeed with glycerine.

The results of Ebstein and Grützner, that by simple extraction of the pyloric and fundal mucous membrane with water an active preparation can be obtained, appears to the author not sufficiently founded. The further critical objections against the existence of a "pepsinogenic" substance are to be seen in the original.

On the Ferments.—O. Nasse, *Vortrag. Sitzungsb. d. naturf. Ges. zu Halle*, 1874 (Abstract in *Centralblatt*, No. 34, 1874). Ebstein and Grützner have already confirmed the statement of v. Wittich, that fibrin absorbs pepsin as explained above. N. also confirms the same, but gives another explanation of the action, in as far as he thinks we have to do here, not with a mere mechanical action, but really with a chemical combination. He has found coagulated albumen fixes the pancreas ferment, and swollen-up amylum, ptyalin. By washing out with ice-cold water the swollen-up amylum can be completely freed from sugar, if it is digested with water at 30°—40°C., then a copious formation of sugar takes place, with liberation of the ferment.

Influence of Bicarbonate of Soda on Dogs.—Lomikowsky (*Berlin. klin. Wochensch.* No. 40, 1873) finds that this drug acts on the intestinal canal, and that under its influence the Peyerian and solitary glands become enlarged. This depends upon hyperplasia of the lymphoid elements, and is likewise observed in the spleen, which also becomes larger. The liver, subject to a temp. of 15° R. during a few hours, shewed no trace of sugar, though in all cases glycogenic substance was detected.

On the Act of Vomiting.—C. Greve, *Berlin. klin. Wochenschr.* July, 1874 (Abstract in *Lond. Med. Rec.* No. 85), reinvestigated the question as to whether the stomach is active or passive during vomiting. Apomorphia was used, and was found to be the most certain and speedy of emetics. Vomiting occurs after division of the vagi. The negative results obtained by Quehl in this respect were due to his having tied the dogs experimented on upon their backs, in which position they hardly ever vomit except when their stomachs are full. When dogs have emptied their stomach in the morning by violent vomiting, they will not vomit in the afternoon when tied either upon their backs or bellies, but will do so at once if set free and an emetic administered. They vomit more easily when placed on their bellies than on their backs. After the injection of apomorphia, apnœa cannot be produced, and *vice versâ.* When vigorous artificial respiration is kept up, it counteracts the emetic power of apomorphia. The centre for vomiting is identical with or close to the respiratory centre. The nervous path along which the irritation is propagated from the vomiting centre to the organs concerned in the act, lies in the spinal cord as far as the sixth dorsal vertebra. When the cord is divided below this point vomiting stills occurs, but not when the point of section is above this vertebra. The stomach takes no part whatever in the act of vomiting. B. Lüttich has also investigated this subject, with special reference to the rôle of the œsophagus in the act of vomiting. *Inaug. Dissert.* Kiel, 1873, 20 pp. (*Centralblatt,* No. 46). The author combats the views of Traube and Rühle, that the longitudinal fibres of the lowest part of the œsophagus by their contraction play an essential part in the introduction of the act of vomiting. In man these fibres consist of smooth muscles and are incapable of executing retrograde contractions. The author is of opinion that all the phenomena can be better explained when it is assumed that an inspiration introduces the act and not any expiration, as Traube supposes. In fact the author could prove this in a dog with a manometer tied into its opened trachea. The vomiting was produced by the injection of apomorphia. By the contraction of the diaphragm, pressure is exerted on the abdominal contraction, which is strengthened by the simultaneous contraction of the abdominal muscles, whilst in the thoracic cavity the air is rarefied. Thereby, that at once, as L. has observed (in opposition to Traube), by direct examination of the larynx in a dog while vomiting, the glottis is closed, the air in the lungs remains rarefied, *i.e.* the sucking power which is exerted on the contents of the stomach remains undiminished. It is true that air can enter the œsophagus from without, the contents of the stomach, however more easily, because on these a positive pressure is exerted. When the abdominal walls are divided transversely and longitudinally, the pressure of the diaphragm and the elasticity of the walls of the stomach suffice to overcome the closed cardiac orifice, or the stomach will become inflated by air swallowed, and the vomiting rendered easier. The latter can also occur with unopened abdomen. An active participation of the œsophagus in the act of vomiting the author could not prove in dogs. After opening the thoracic cavity a complete act of vomiting could not take place. Experiments in which wax-balls were introduced into the œsophagus opened anteriorly, speak against the occurrence of antiperistaltic movements of this organ.

Liver.

On the Formation of Glycogen in the Liver.—B. Luchsinger, *Pflüg. Arch.* 1873, viii. 289 (Abstract in *Centralblatt*, No. 10, 1874). This author has repeated the experiments of Weiss with feeding on glycerine (*Centralblatt*, 1873, 552), and adds experiments with other easily oxydisable substances. The experiments were conducted partly on hens and partly on rabbits. On injecting glycerine (42 grms. and 60 grms.) into the stomach, in two experiments, the author found 0·55, and 0·71 grms. glycogen; on injecting grape-sugar (50 grms.) 1·678 grms. more, although sugar from the experiments of Scheremetjewski is oxydised with more difficulty, *i.e.* according to the view of Weiss, is less fitted to protect from use the glycogen originating in the liver. The estimation with circular polarisation shewed that the glycogen obtained by feeding with glycerine is identical with normal glycogen. As in hens, on which the first three experiments were made, so also in hungered rabbits, a considerable quantity of glycogen was found in the liver, and also in the muscles, after the injection of glycerine. According to the theory of Weiss subcutaneous injection of glycerine should have the same effect as injecting it into the stomach. One experiment (subcutaneous) yielded no glycogen in the muscles, but traces in the liver. In all 50 ccm. glycerine were injected. After the third injection the animal had a fit, but, with this exception, was throughout well. An experiment with feeding on fat gave a negative result; the liver contained fat richly, but no glycogen. In spite of the large quantity of easily oxydisable materials in the body, the glycogen was not preserved from oxydation. Experiments with tartarate and lactate of soda gave no glycogen in the liver, or only traces. The general result is that substances known to be easily oxydisable are not able to cause an accumulation of glycogen in the liver, in the sense of the "Ersparnisstheorie."

The author then investigated whether other sorts of sugar did not produce other glycogens corresponding to them. Experiments with lactose and inulin yielded also a glycogen, which in the latter case was proved to be identical with the normal glycogen. Glycerine excepted, according to these experiments, it is the carbo-hydrates exclusively which occasion a formation of glycogen in the liver. The author then attempts to shew that glycerine can go over directly into glycogen, and cites a series of relationships between glycerine and sugar, also the formation of glycerine from sugar in the alcoholic fermentation, and the change of glycerine into sugar by the substance of the testicle after Berthelot. Supported by this, and the negative results with easily oxydisable substances, the author is of opinion that glycerine also goes over directly into glycogen.

MOVEMENTS OF THE BILE.—Kowalewsky (*Pflüg. Arch.* VIII. Hft. 11—12) operated upon curarised cats. He found that: 1. The motive power for the bile is not constant, either in different animals, or in one and the same animal at different times, *e.g.* the pressure in curarised cats varied from 12 to 20mm. Hg. The different animals shewed variations at different times: 12·4—14·1 or 17·5—18·3 or 19·20mm. Hg. 2. These last-cited variations depend upon the blood-pressure in the large arteries; each increase of blood-pressure being followed by an increase of the pressure of the bile. A certain time, however, generally elapses before increase of the arterial blood-pressure is followed by a corresponding change in the bile-pressure (estimated by the manometer); the latter is also not the immediate consequence of the former, but depends upon the change in the secretion or on the absorption from the bile-passages. 3. The greatness of the resistance to the outflow of the bile into the intestine also varies, even in one and the same animal (in curarised cats). 4. On comparing the greatness of the motive power with the resistance, it is at once observed that a cessation of the secretion of bile, or a retrograde suction under physiological conditions, cannot occur, but a stand-still in the outflow of the bile into the intestine may occur, until the pressure on the walls of the bile-ducts has reached 3·5 to 7·5mm. Hg. From this moment the bile must flow in drops into the intestine. This latter must occur oftener in fasting animals, for in them the gall-bladder is generally found tensely filled. Thereby can be explained the great difference which exists between the bile from the gall-bladder of fasting animals and the freshly secreted liver-bile, for with a tensely filled gall-bladder the continually secreted bile must flow into the intestine without previously going into the gall-bladder.

"Influence of Injections of Bile on the Organism." V. Feltz and G. Ritter, *Gaz. Méd. de Paris*, No. 25.

GASOMETRIC ANALYSIS OF BILE.—Bogoljubow (*Inaug. Diss. Kasan*,

1873. *Pflüg. Arch.* VIII. ibid.) has made comparative gasometric analysis of bile, and found that the quantity of chemically united CO_2 in the bile from the gall-bladder of fasting animals is almost none, and the quantity of free CO_2 may fall to 2 vols. per cent.; whilst the fresh bile from the liver, secreted at the same time, contains 64 per cent. of chemically united CO_2 and 7 per cent. in the free condition. (*Lond. Med. Rec.* II. No. 69, 1874.)

SPECTRUM OF BILE.—Dalton, *New York Med. Journ.* June, 1874. (*Lond. Med. Rec.* No. 85), discusses first, the spectrum of fresh bile, which depends on the presence of its normal colouring matters; and secondly, the spectrum presented by the coloured fluid of Pettenkoffer's test, which depends for its production on the presence of the biliary salts. His results are: 1. The spectrum of bile is characterised, as a general rule, by an absorption-band at C. 2. The existence and intensity of this band are proportioned to the predominance of green in the colour of the bile. 3. The spectrum of bile is also distinguished by a diminution or absence of the orange and yellow, and a corresponding extension of the red and green. 4. There are sometimes also two other absorption-bands, comparatively uncertain and ill-defined at D and at D 30 E. 5. The pure biliary salts in alcoholic solution, treated by Pettenkoffer's test, give a spectrum with absorption-bands at E and F. 6. In a watery solution, treated by the same test, they give a spectrum with but one absorption-band, viz. at E.

ACTION OF BILE IN PROMOTING THE ABSORPTION OF FATS.—C. H. Williams (*Boston Med. and Surg. Journ.*) has investigated this subject under the superintendence of Bowditch. His conclusions are: 1. That the passage of neutral fats through capillary canals or pores is favoured by the presence of bile in those pores. 2. That this action is increased when the bile is rendered alkaline, and diminished when it is acid. 3. That the action cannot be due to the bile changing the form of the pores. 4. That after passing through membrane moistened with bile the fats appear more finely divided than with membranes wet with other substances, apparently shewing that the drop-tension or cohesion of the fat has been affected.

ACTION OF MUSCARINE ON THE PANCREATIC AND OTHER SECRETIONS.—Prevost confirms the results of Schmiedeberg and Koppe on the action of the toxical principle of *Agaricus muscarius* on the heart, pupil, &c., and on the antagonistic action of atropine.—In *Comptes rendus*, Aug. 10 (*Lond. Med. Rec.* No. 87), the results of experiments on the action of muscarine on the pancreatic and other secretions are recorded.—1. *Action on the pancreatic and biliary Secretions.* The experiments were made on dogs, in which the openings of the pancreatic and biliary ducts into the intestine were exposed. Whether the animal was in digestion or fast, the pancreatic secretion was notably increased after the injection of some milligrammes of muscarine into a vein. The excessive secretion ceased after intra-venous injection of one or two milligrammes of sulphate of atropine. There was also a great increase of biliary secretion; from a feeble flow before the injection of muscarine, it became abundant. The excessive secretion ceased, and the normal state was restored, after atropine was injected.—2. *Action on the Urinary Secretion.* After intra-venous injection of muscarine the change in the flow of urine from the ureters was observed in dogs, cats and rabbits. The bladder was exposed and slit open so as to observe the entrance of the ureters into this viscus. Injection of muscarine into the veins diminished the urinary secretion, and almost stopped it completely when the dose was strong. In all these cases on the other hand the lachrymal, salivary, biliary and mucous secretions were considerably increased. The injection of a few milligrammes of atropine into the veins suffices to restore the urinary secretion.

"On the Formation of bile-pigment from the colouring matter of the Blood." J. F. Tarchanoff, *Pflüg. Arch.* IX. 53 and 329.

The Genito-Urinary System.

"The phlogistic properties of Urea." A. Murow, *Gaz. Méd.* 447, 1873.——"Influence of Coffee and Tea on the excretion of Urea." Rabuteau, *Comptes rendus*, 1873, LXXVII. 489.——"The microscopic structure and mode of formation of Urinary Calculi." The *Dublin Journal*, LXVI. 493.——"Diuretic action of Digitalis." T. L. Brunton and H. Power, *Centralblatt*, No. 32, 1874.——"Simple apparatus for the Estimation of Urea by the Nitrogen process." G. Steel, *Edin. Med. Journ.* August, 1874.——"New arguments with reference to the formation of Urea in the Kidneys." Murri, *Lo Sperimentale*, Sept. 1873.——"On the Alkalinity of the Urine." Feltz and Ritter, *Journal de l'Anatomie*, Feb. 1874, 311. (Abst. in *Lond. Med. Rec.* No. 75, 1874.)——"Fouilhoux on Variations in Urea." *Lond. Med. Rec.* No. 71, 1874.——"Urea in Vomit." Juventin, *Gazette Méd. de Paris*, April 25th (and ibid.).——"The presence of Albumen in Urine." H. Senator, *Virch. Arch.* LX. 476.——"Physiology of the Menopause." Cohnstein, *Virch. Arch.* LXI. 100.——"Chemical Examination of Saccharine Urine." Fowler, *Lancet*, Sept. 19, 1874.——"Experiments on the process of the Secretion of Urine." A. Neisser and R. Heidenhain, *Pflüg. Arch.* IX. 1.

TEST-PAPER FOR UREA.—Musculus, *Acad. des Scien. Gaz. Méd. de Paris*, 1874, No. 4. The ammoniacal fermentation of urine, according to Pasteur and Tieghem, is caused by the presence of torulæ which can be collected on the filter upon filtering putrid urine. If this paper is then washed with water until it shews no sign of alkaline reaction, and then dried at a gentle heat, a very sensitive reagent for urea is obtained. It is best to tint this paper with curcuma and dry it again. When a piece of such paper is placed in a solution of urea, in a few minutes carbonate of ammonia is formed by the action of the revived torulæ upon the urea, and the paper becomes of a brown colour. The fluid to be tested must have a neutral reaction.

A NEW CONSTITUENT OF URINE.—F. Baumstark, *Ber. d. Deutsch. Chem. Ges.* Bd. 6, 883 (from *Centralblatt*, No. 25, 1874). This author found a new constituent of urine first in the urine of a dog fed on benzoic acid, then in icteric and lastly in normal human urine. This body does not pass over with the ether in the ordinary process employed for testing for hippuric acid, but remains dissolved in the remaining watery fluid. By addition of acetate of lead it is precipitated and isolated by H_2S from the lead precipitate. The compound crystallises in white columns similar to hippuric acid. It has the composition $C_3H_8N_2O$, and forms light combinations with acids. From its reaction with nitrous acid by which flesh-lactic acid is formed, and from the action of baryta water, the author gives this substance preliminarily the rational formula $NH_2—CO—C_2H_4—NH_2$.

On the Removal of Alkalies from the Animal Body.—Joh. Kurtz. *Inaug. Diss.* Dorpat, 1874. 50 pp. (From *Centralblatt*, No. 36, 1874.) The experiments were all made on a dog of 24·7 kilos weight, which was so placed that it could empty its urine into a vessel at distinct times of the day.

I. In two series of experiments the influence of the supply of sulphuric acid was tested. During the first series the dog received on five consecutive "normal days" 1100 grm. flesh and 1000 ccm. water. On the following six days beyond this, sulphuric acid daily (per stomach-pump), on the first day 3 grm., on the second 4, on the third and fourth 5 grm., on the fifth and sixth days on each 6 grm. diluted with water. The six "acid days" were followed again by three normal days. Daily, the acidity, urea, uric acid, sulphuric acid and phosphoric acid in the urine were estimated. On the last normal day and on the first and last acid days beyond these the Cl, K, Na, Ca and Mg were estimated. Throughout the whole time the condition of the dog was good. The changes in the urine were: marked increase in the acidity and of the sulphuric acid, less increase of the chlorine; an increase of the bases was also present, but still not important. If we reckon how much Na the acids found require for their saturation, and reckon also all the bases as Na, we obtain

	Natrium required	found.
Normal day	4,540 grm.	5,055 grm.
First acid day	6,186 ,,	5,503 ,,
Second acid day	6,589 ,,	6,021 ,,

Whilst on the normal day an excess of bases is present, an excess of acids is to be observed on the acid days.

In the second series of experiments, which lasted five days, the dog received as food along with water extracted horse-flesh, in order to supply it with the minimum of alkaline salts, on the fourth day 7 grm. of concentrated sulphuric acid. In the urine

	Natrium required	found.
On the Normal day	2,484 grm.	0,803 grm.
,, ,, Acid day	6,286 ,,	1,963 ,,
,, ,, day following	2,857 ,,	0,464 ,,

In this experiment considerably more acids than bases were excreted, the latter are not even sufficient to unite all the H_2SO_4, when one abstracts from all other acids. Nevertheless free H_2SO_4 was not proved in the urine. Constantly, under the influence of the supply of H_2SO_4 there was an increase of urea.

II. Bunge, experimenting upon himself (*Centralblatt*, 1873, 742), observed after taking phosphate of potash an increase of soda to 4,715 grm. in the urine of the following day; on the next days he found besides much potash less soda than on the previous days. Bunge explained this result by the decomposition of the absorbed phosphate of potash with the chloride of sodium in the blood, into chloride of potassium and phosphate of soda, which were both excreted. One must now ask if this action of the potash salts would result even with the greatest possible exclusion of soda from the food, *i.e.* when the blood is poor in these salts. One experiment of Gäthgens, not with phosphate of potash but with chloride of potash, which the author cites, shews that under these circumstances an increase of the soda in the urine cannot be proved, but on the contrary rather a diminution. The same result was obtained by an experiment of the authors with phosphate of potash. The same followed directly from the experiment with H_2SO_4, by which the supply of disposable alkali was surely reduced to a minimum. The diet consisted of 500 grm. of extracted flesh, 1200 ccm. water and 10 grm. so-called neutral phosphate of potash. The urine shewed no increase in the soda, on the contrary a constant diminution to a minimum. From this it follows from the present question, that the possibility of the withdrawal of soda from the body depends upon the giving up of phosphate of potash from the supply of soda present at the moment. One part of the soda is bound so fast to the constituents of the body that it is not affected by the ordinary action of affinity. An experiment of Kemmerich shews this relation, K. found in a dog in spite of rich supply of potash salts that the quantity of potash in the blood remained unchanged. Very remarkable is in this experiment the increase of the acidity of the urine on the addition of alkaline reacting salts; clearly from the phosphate of potash during its passage through the organism a part of its bases was removed, and acid phosphate of potash formed, which passed over into the urine.

III. Böcker and Reinson have shewn that a single supply of phosphate of soda is followed by an increase in the excretion of potash: a supply of soda salts kept up for a long time has only lately been tested. Gäthgens and Frey fed a dog for a long time on exhausted horse-flesh, and gave it in addition daily, at the beginning 4, later 2 grms. of common salt. The excretion of potash remained throughout the same, and no increase could be observed. Also here the results of the author join to those of Gäthgens. The dog received again 500 grm. boiled-out horse-flesh, 1000 grm. water, and in addition 15 grm. so-called neutral phosphate of soda. On the first day a small increase in the excretion of potash, in unison with Reinson, was observed; already even on the second day it sank again to the normal: certainly the withdrawal of potash is only minimal.

In the second part of the experiment, an essential difference is shewn by the excretion of soda, opposite to the potash excretion: whilst the excretion of soda becomes always smaller, the potash excretion, one day with another, remains unchanged. The author confirms the correctness of an assertion formerly made by Salkowski that the potash salts are excreted in the degree in which they become free by the decomposition of the tissues, whilst for the soda excretion the same cannot be affirmed. The investigations were made under Gäthgens' direction.

DIABETES.—Dr Pavy (*Lancet*, Aug. 29, 1874) finds that injection of defibrinated arterial blood into the portal system occasions a saccharine state of the urine, in one experiment 15 grs. of sugar to the fluid oz. of urine. When defibrinated venous blood was injected no sugar was detected. He further finds that by the inhalation of puff-ball smoke a strongly diabetic state of the urine may be induced, and that the effect is accompanied with such a modification of the circulation that the blood flows through the vessels, as is the case after section of the sympathetic, without becoming properly de-arterialised. His experiments, he considers, suggest that, in diabetes of the human subject, the blood, in consequence of vaso-muscular paralysis, is allowed to reach the portal system in an imperfectly de-arterialised condition and thus determines the escape of sugar from the liver.

Bone.

"Mineral Inanition, and the influence of Phosphate of Lime on the transformation of Albuminous Substances." *Gaz. Méd. de Paris*, 1874, No. 5. "Spongiosa of the Vertebræ and Ribs." K. Bardeleben, *Centralblatt*, Nos. 29 and 34.——"Normal and pathological growth of the long Bones." G. Wegner, *Virch. Arch.* LXI. 44.——"Architecture of the Spongiosa." P. Langerhaus, *Virch. Arch.* LXI. 229.——"The marrow of Bone as an organ for the formation of Blood." E. Neumann, *Pflüg. Arch.* IX. 100. [Reply to Ch. Robin.]

EFFECT OF FOOD ON THE COMPOSITION OF BONES.—H. Weiske and E. Wildt (*Zeitsch. f. Biolog.*, IX. Heft IV. 541, 1873) in a former series of experiments upon goats shewed that although the withdrawal of lime or phosphoric acid from the food of adult animals led to fatal consequences, yet that it had little or no influence on the composition of the bones, and in particular did not make them more friable. The present series of experiments were designed to test the effects of such food upon young animals. The animals selected were Southdown lambs of about 10 weeks old. One of these was fed on food poor in lime, a second on food poor in phosphoric acid, and a third on normal diet. After 55 days various bones were analysed, and the general result was, that just as in adults so in young animals, no remarkable change was produced in the composition of the several bones by the difference in the diet, or, in other words, that the composition of the bones is independent of the nature of the food. The bones were, however, stunted in their growth.

Muscle.

"On the Doctrine of Tetanus, with Observations on Testing the Electrical Excitability of Motor Nerves." W. Erb, *Arch. f. Psych. v. Nervenkrankh.*, 1873, IV. 271 (Abstract in *Centralblatt*, No. 12, 1874). ——"On the Doctrine of Tetanus." F. Riegel, *Deutsches Arch. f. klin. Med.* 1873, XII. 399 (Abstract in *Centralblatt*, No. 12, 1874).—— "On the Difference of the Action of Caffenic on Rana Temporaria and R. Esculenta." O. Schmiedeberg, *Arch. f. exper. Pathol. v. Pharmacol.* 1874, II. 62 (Abstract in *Centralblatt*, No. 32, 1874).—— "New Experiments on Human Locomotion." Marey, Abstract in *Lond. Med. Rec.* No. 83.——"Remarks on Preyer's Myo-physical Laws." B. Luchsinger, *Pflüg. Arch.* VIII. 538.——"On the Muscular Spectrum." L. Ranvier, *Gaz. Méd. de Paris*, No. 24.

Physical Properties of Muscular Substance.—Albert Adamiewicz (*Centralblatt*, No. 22) after a large number of experiments concludes that the muscles of the trunk play a very important rôle in the process of animal heat. This is due to their *physical* properties.

1. Muscular substance is an exceedingly bad conductor. It conducts heat worse than water. The weak capability of conduction of the layers of the trunk muscles can be explained in the living animal on physical principles.

2. With the small diathermancy of the muscular substance coincides its greatest power for absorbing heat, which at the ordinary temperature of warm-blooded animals may be placed at four calories.

3. The muscular substance possesses the highest known specific heat of solid and fluid bodies and *exceeds that of water considerably.* Further details are promised.

Reducing Power of Active Muscles.—R. Gscheidlen, *Pflüg. Arch.* VIII. 506 (Abstract in *Centralblatt*, No. 30, 1874). To the proof attempted by Grützner (*Journ. of Anat. and Phys.* VIII. 213) that active muscle uses oxygen and acquires the capability of removing from itself easily reducible stuffs, Gscheidlen used sulphate of soda, which, with a reducing agent, easily passes into a sulphurous salt. He injected into the abdominal vein or under the skin of the back of frogs several ccm. of 1—10 per cent. solution of sulphate of soda, divided one ischiadic nerve, and then tetanised the frog either from the spinal cord with the induced current, or by means of strychnia. After tetanisation from 1 to 8 hours, the muscles of the limbs were each minced and rubbed up with water and filtered through pulverised glass (filtering through paper is not to be trusted, for often the paper contains sulphate of ammonia). If to the extract so obtained, iodide of potassium clyster and dilute sulphuric acid is added, in the extract of the active muscle after ½ to 1 hour there occurred a blue coloration, in that of the inactive muscle only after 34—36 hours or later. In the former case a change from nitrate into nitrite had taken place, in the latter not. Other re-agents also shew this change from nitrate into nitrite, thus the extract of active muscle is coloured more yellow with diamidobenzoic acid than that of the passive muscle. The reaction with brucin and sulphuric acid also shews the greater quantity of unchanged nitrate in the passive muscles. Or the muscles which have been active, and also those which have been passive, may be rubbed up separately with a solution of sulphate of potash; in the active one formation of nitrite occurs, in the inactive one none. These reducing substances of muscle are soluble in alcohol; the alcoholic extract of the active muscle yields nitrite reaction, that of the passive not. The reducing active is also expressed with indigo when the air is sufficiently excluded. If the extract is placed with a few drops of indigo solution in a well-closed flask, with the fluid of the active muscle the blue colour is lost at once, with that of the passive muscle very much later. Experiments on mammalia (rabbits) did not give such decided results, though here also the blue coloration appeared earlier with K. I. clyster with the active muscle: the difference however was not so great as in the frog.

INFLUENCE OF MUSCULAR WORK ON THE DECOMPOSITION OF ALBUMEN WITHIN THE HUMAN ORGANISM.—F. Schenk, *Arch. f. exp. Path. &c.* 1874, II. 21. (From Salkowski's Report in *Centralblatt*, No. 24, 1874.) In these experiments the arrangement was such that S. on all the days took the same quantity and quality of food until the N.-equilibrium occurred, and then a considerable amount of work was executed. The food consisted of 400 grms. flesh, 375 grms. bread, 250 grms. potatoes, 14 grms. NaCl, 100 grms. butter, 500 ccm. milk, 1000 ccm. water, and the same of beer. The quantity of N. was reckoned from the quantity of urea, and this itself estimated by titriring after precipitation of the urine with silver solution and baryta. In the first series of experiments from 22nd Jan. to 15th Feb. on the sixth day N.-equilibrium occurred; four days later the period of work was begun, which was continued during three days and the two intervening nights. During the night the work consisted of walking 32 kilometers; during the day, work in the laboratory, walking and gymnastics. The urea shewed a decided increase on the work days, but (the mean = 46·2 grms. to 51·2, 55·6, 51, 52·3) which in proportion to the work produced is still small. The following fourteen days were spent at rest, and then two consecutive nights passed without sleep, to ascertain the effect of want of sleep without work. The quantity of urea was not influenced thereby, and shewed a constant value. The influence of want of sleep was tested by Nencki, in whose laboratory the experiments were made. The urea previously was 28·9, 30·4, 29·8, 28·4; during the time without sleep, 28·4, 28·7, 28·6. His food consisted of 300 grms. flesh, 180 grms. bread, 250 grms. potatoes, 14 grms. NaCl, 100 grms. butter, 500 ccm. infusion of tea, wine, and the same of water. A second experiment was made in September with high temperature outside. The work performed during the three days and the two intervening nights was similar to that on the former occasion: an increase in urea could not be proved; even the uric acid and creatinin estimated on the last day of work, and on the day after the work, shewed no important increase. The author therefore concludes that a distinct near connection does not exist between muscular work and the excretion of urea, and leaves it undecided whereupon the difference between the two series of experiments rests.

Temperature.

"On the influence of Brandy on the bodily Temperature, the Pulse, and the Respirations of healthy men." Parkes, *Pro. Royal Society*, Lond. 1874, No. 150.——"Fever after Transfusion." P. Liebrecht, *Centralblatt*, No. 37, 1874.——"Influence of Alcohol on the Temperature of the Human Body." Riegel, *Deutsch. Arch. f. klin. Med.* XII. pts. 1 and 2. (Abst. in *Lond. Med. Rec.* No. 71, 1874.)

TEMPERATURE OF HEART AND LUNGS.—Albert and Stricker (*Stricker's Jahrbuch*, 1873) object to the usual mode of determining the temp. of the heart, that the thermometer is in contact both with the muscular tissue and with the blood, and they find that considerable difference exists between the two. Thus a thermometer introduced through the diaphragm and imbedded in the substance of the left ventricle, shewed a temp. of 0·5° to 0·7° C. or more than a degree F. higher than another introduced into the cavity of the ventricle through the auricular wall. Little difference (0·1 C.) existed between the blood of the left ventricle and that in the aorta in favour of the former. Further experiments shewed that the blood of the right auricle is warmer than that of the sup. vena cava, and that in the ventricle the temp. is higher as the apex is approximated, probably owing to the admixture of the blood of the coronary vein, which has circulated through the warm muscular tissue of the heart. They are of opinion that there is a decided refrigeration of the blood as it passes through the lungs, though the heat lost is small, and is partly compensated for and restored by the higher temp. of the walls of the left ventricle. They found, lastly, that the blood of the aorta is warmer than that of the vena cava descendens.

REGULATION OF HEAT.—F. Riegel (*Virchow's Arch.* LIX. 114). Experimenting on dogs, R. brings new proofs of the changes in the distribution of heat, under the influence of peripheral cooling. On these dogs, the temperature was measured simultaneously in several superficially and deeply situated places. As well by local as by general withdrawal of heat, the temperature sank in the interior (vena cava inf. aortæ thorac.) in most cases at once, seldom after a minimal recovery of short duration; slower and smaller was the decline in the rectum and vagina and quite special in the muscular layers ("intermediary layer" of Senator and "Zwischenschicht" of Rosenthal). The explanation of these different changes in temperature the author finds in change of the circulation produced by the action of cold.

INVESTIGATIONS ON FEVER.—Ed. Albert, *Berichte des naturwiss.-med. Vereins zu Innsbruck*, 1873, Sep. Abdr. 1874. 38 pp. (Abst. in *Centralblatt*, No. 30, 1874.) As a supplement to his previous experiments with Stricker, on the effects of the exclusion of a large vascular area, the author injected milk of starch into the art. profunda femoris on both sides, and ligatured at the same time the femoral artery below the origin of the profunda. The experiments were made on dogs. In a series of experiments, apart from the variations of temperature following the operation, there occurred a greater or less increase of the rectal temperature with shivering, the increase lasting to three days. The animals were then depressed, had no desire to eat; but recovered again. In other cases on the contrary the temperature fell, the dogs had no 'typical' chill and were very restless. An increase of temperature also occurred when an embolus was produced by the injection of starch in water into the splenic vein. The ligatures of the A. femoralis and profunda when done on one side were followed in one animal by increase of temperature with shivering; when done on both sides only once in three experiments.

Miscellanea.

Resuscitation after Poisoning.—R. Böhm (*Centralblatt*, No. 21, 1874) of Dorpat has made the observation that the action on the heart and nervous system of warm-blooded animals, which is produced by doses of the salts of potash, which till now have been held as fatal, can be removed by artificial respiration and moderate compression of the thorax in the region of the heart exerted during passive expiration.

A new Sign of Death.—E. Bouchut, *Comptes rendus*, LXXVIII. 1874, 631. According to B. immediately after death has occurred a development of gas takes place in the retinal vein, which can be easily distinguished by the ophthalmoscope through the interruption of the column of blood.—"On a certain and immediate Sign of Death." Danis, Abst. in *Lond. Med. Rec.* No. 67, II. 1874.

"On the Abiogenesis Question." D. Huizinga, *Pflüg. Arch.* VIII. 551. (Abst. in *Centralblatt*, No. 32, 1874.)——"On the Galvanic introduction of different fluids into the uninjured living organism." *Reichert and du Bois Reymond's Arch.* 1873, 505.——"Action of the Alkaloids." M. J. Rossbach, *Verhandl. d. Würzb. phys.-med. Ges.* VI. 1874, 167. (Abst. in *Centralblatt*, No. 35, 1874.)

Text-Books.

"Vorlesungen über Physiologie," von Ernst Brucke. 2 vols. Wien, 1874, Wilhelm Braumüller.

"Grundriss der Physiologie d. Menschen," von L. Hermann. Fifth Edition, Berlin, 1874, August Hirschwald.

"Lehrbuch d. Experimentellen Toxicologie," von L. Hermann, Berlin, 1874, August Hirschwald.

"Compendium d. Physiologie d. Menschen," von A. Fick. Second Edition, Wien, 1874, Wilhelm Braumüller.

"Grundzüge der physiologischen Psychologie," von W. Wundt. 2 vols. Leipzig, 1874, W. Englemann.

"Lehrbuch der physiologischen Chemie," von E. F. V. Gorup-Besanez, Braunschweig, 1874, F. Vieweg and Sons.

Journal of Anatomy and Physiology.

ON THE FREEZING PROCESS FOR SECTION-CUTTING: AND ON VARIOUS METHODS OF STAINING AND MOUNTING SECTIONS. By Lawson Tait, F.R.C.S.

If I may take the directions given in Foster and Balfour's *Elements of Embryology* as being an exposition of the most recent methods of section-cutting, I can only feel that I have, by patient endeavours, been able to achieve a success which is not much known beyond the limited circle of those who have seen my work. I therefore hasten to describe some improvements I have made in the methods of section-cutting, which seem to me to constitute as important an advance over the rude hardening and imbedding processes, as the results obtained by them were superior to the sections made by double knives.

As often as I have asked physiological workers, have you used the freezing process for section-cutting? so often have I been answered that they had tried it a little, but that it had not proved satisfactory and that they had given it up. The various reasons given for failure I always found were such as a little patience on my own part had already overcome, and now I think I have made the process and the apparatus perfect.

First let me say, that the results of my work so far, especially in pathological investigations, have led me to this conclusion, that no results obtained by the examination of tissues which have been chemically interfered with by such reagents as chromic acid, picric acid, osmium, alcohol, &c., are trustworthy; for the appearances in specimens of the same tissue which

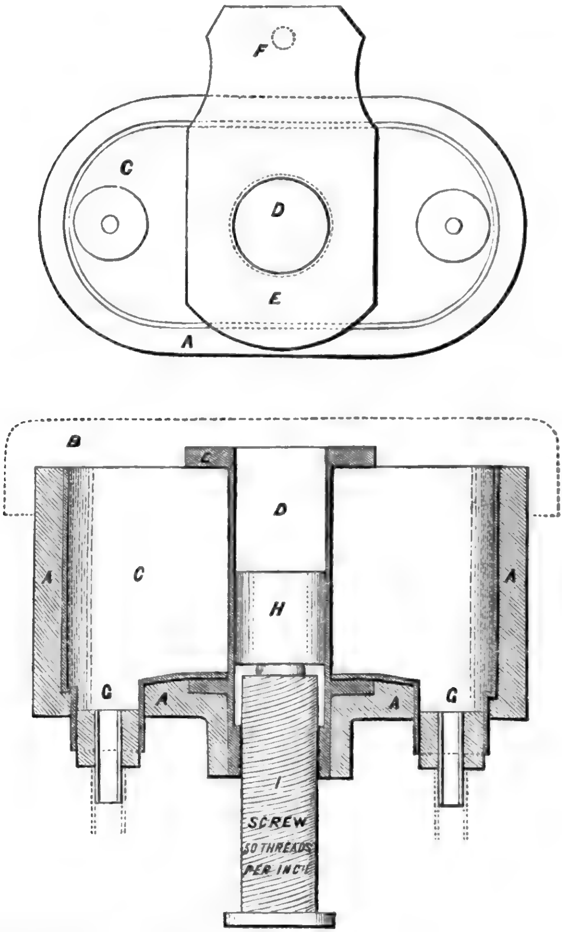
I have seen in sections so treated, have in some instances been so widely different from those observed in the unaltered tissue that I hesitate to receive descriptions which have been taken from artificially altered specimens. Further, different methods of staining give such wholly different results, that a great deal of ground which seems settled now will have to be gone over again. This is especially the case in embryonic structures.

It cannot be urged against the freezing process that it alters tissue in any way, for every one knows that in less complex organisms, even as high up as the lower vertebrates, the whole animal may be completely frozen, and on being carefully thawed its life-functions may be resumed without apparent injury.

It is evident, therefore, that sections of a perfectly fresh tissue which has been frozen, will most closely represent living structure: and for the same reason, any staining process or method of mounting which is to be regarded as truthful, must be the result of some substance which is as indifferent as may be. Therefore I have almost entirely discarded all terebinthinate vehicles for mounting, and all such violent treatments of sections as soaking them in a strong solution of alum or calcium chloride, and when these processes and my own have given different results, I have preferred the latter.

The chief difficulty with the freezing process has been, that in the apparatus usually employed the amount of the freezing mixture engaged has been too small for the surrounding circumstances; and thus of Prof. Rutherford's apparatus I have always heard it said, that it either never completely freezes the tissue, or that the complete freezing lasts for so short a time as to be of little use. This I can readily understand, for Dr Rutherford directs methylated spirit to be placed in the well to prevent the screw freezing, and that the tissue be imbedded in a solution of gum, &c., so that the process is made very complicated. Before the appearance of Prof. Rutherford's description of his instrument (July, 1873), I had had one almost identical in use for many months, but I have since had to modify it very much on account of repeated failures.

The groundwork of the instrument is the section-cutter of my friend Mr Stirling, described and figured in the third volume of this *Journal*, to which is added a freezing tank (*c*), four and a half inches long and two and three-quarters deep, oval, and concentric with the object-well D. Dr Rutherford



A. Fixed covering of cork.
B. Moveable cork cover.
C. Tank for freezing mixture.
D. Well for tissue with loose moveable plug H.
E. Level brass plate with
F. Lip for fixing it to table.
GG. Drainage wells fitted with moveable quilled cork and rubber tube.
H. Travelling plug.
I. Screw with milled head.

The apparatus is made by Parkes and Son, St Mary's Square, Birmingham.

objects to this arrangement, because the right half of the well gets in the way of the hand, but I have found this difficulty very trifling and soon overcome in practice; whilst my arrangement has the advantage that the freezing mixture can be packed in from either side, and that therefore the well does not get surrounded by a mass of salt, left by the more rapid melting of the ice, which has to be removed by picking or washing, to the great hindrance of the process. This is one of the great objections to Rutherford's instrument. Outside the well I have placed a coating of cork, A, fixed by white lead and marine glue, half-an-inch thick, and firmly secured in its place by a long strip of Leslie's sticking plaster wound spirally round, and then the whole is painted white. Every possible surface of the metal is covered by the cork, so that as much heat as possible is kept out. The whole instrument is fitted with a moveable cork cover, B, which is likewise painted white. Cork is the only good non-conductor which is available for this purpose, for it does not absorb water when treated as I have described, as flannel or almost anything else is sure to do, and thereby become a very good conductor of heat. The instrument is also provided with two drainage wells, GG, which are closed by quilled corks, so that while a fair drainage is possible through the tubes, the whole well may be cleared out at any moment, so as to get rid of the slushy salt, which is one of the great obstacles to the process. Mr W. P. Marshall suggested this and the double sloping bottom to me, and it is a manifest improvement. The best freezing mixture is made by intimately mixing one part of dry salt with two parts of dry snow. If ice be used it should be pounded very small and drained on a cullender. If the worker does not mind the extra expense, the substitution of one-fifth of calcium chloride for the salt will very much save his time, but it will damage his instrument, and he had better mind that he does not get his fingers chilblained or even frost-bitten.

The well being carefully charged, the cap should be put on and the instrument be screwed to the table while the tissue is being got ready. If any salt should by accident have got into the well it must be washed out, as it will materially retard the freezing. If the tissue to be frozen has been in any hardening solution, especially alcohol, it must be soaked for some hours in distilled water, which requires to be repeatedly renewed. Everything being ready the cap is to be removed, and the well D is to be filled with pure water. A ring of ice will be seen at once to form round the inside of the tube, and to this the tissue is to be held by a needle till it is fixed as wanted, and then the cap is to be replaced, fresh mixture having first been added to both sides of the tank, if required, and pushed firmly against the outside of the well. The corks in the wells GG must be removed now and then to ensure that the sludge gets freely away, and the tissue may be arranged from time to time by a needle, so that it may be made to take any required position with absolute accuracy, an advantage which no other methcd of imbedding possesses. If the tissue is absolutely fresh, the whole process will not take fifteen minutes, but if it has been previously hardened in alcohol, the freezing may be protracted. To facilitate its progress, the water in the well which has not frozen should be from time to time lifted carefully out by a pipette and replaced by fresh distilled water, the alcohol being driven out of the tissue into the water by the freezing, so that it may absolutely prevent the completion of the process. I have often had to change the water in this way half-a-dozen times, but I have never failed in getting my sections made.

After the freezing is once perfect, you have only to re-pack the tank, replace the cap and cover the apparatus with a towel, and you can leave it for hours, with the perfect assurance that it will remain in good working order.

When it is desired to cut sections, if the screw I be found to be frozen tight[1], back it a little, or put a drop of glycerine between it and the collar; or if the tissue to be frozen be a piece of large size, so that the plug H must be low down in the well, put some glycerine in the well before you insert the plug. This should never be done, however, if it can be avoided, for it is very rare indeed that any great difficulty occurs in advancing the screw I upwards. This screw has fifty turns in the inch, and as, when the freezing is complete, it is quite easy to cut a

[1] A simple method of preventing the screw being frozen is to drop a little melted tallow over the travelling plug I, so as to make its surface water-tight.

section when the screw has been turned only a tenth of a revolution, five hundred sections may be cut from an inch of tissue. Some of my sections I believe to be thinner than this. I purpose having a ratchet drill-head arrangement adapted to the milled head of the screw, so that it may be more easily moved and the thickness of the sections known precisely. Twelve notches on the milled head would, by one movement, give sections one six hundredth of an inch in thickness.

To cut the sections, any knife with a straight sharp edge may be used, but continuous patient practice is necessary to cut them well. I use an ordinary razor ground flat on the side and straight on the edge, and I cant it a good deal so as to get a smooth section. If a tissue is being cut of which parts may be dislodged, such as an embryo, or an eye, the section must be made rapidly, so that it curls up and does not thaw on the knife; and if slides be kept in readiness on a frozen bath, the sections may each be leisurely arranged on a slide in the exact position required, in a way which would excite the astonishment of any one who has been grieved by seeing his best sections torn in pieces by the adhering wax or paraffin.

If the tissue be homogeneous the section may be made more slowly and allowed to thaw on the knife as it is made. In this way much thinner and more uniform sections are obtained, and they are easily floated off on to the slide by a few drops of some indifferent fluid; or they may be placed in a staining bath.

Having secured perfect success in these details, and having been convinced that if perfectly trustworthy results were to be obtained the tissues must be examined fresh, I was almost beaten by the unexpected difficulty that the freezing process drives out the air which is contained in fresh tissue, in the form of myriads of minute bubbles, which render the thinnest section perfectly useless. They resisted all kinds of treatment by needle and air-pump, until I remembered that boiled water is a potent solvent for air, and I found that a few drops, or a gentle stream of water so deprived of its air, at once removed from my sections every trace of air-bubble: and I have since found that no air-bubble, of microscopic size, will resist this treatment. For delicate embryonic tissue, unless it is intended to stain the sections with silver, a solution of salt, one or two per cent, and which has been recently boiled, had better be used for this purpose. If the tissue has previously been injected with Prussian blue, the water should contain a little free muriatic acid.

Of substances which act as tissue-stains, I find that there are two classes, one which simply colours the whole mass, exclusive of fat, and the other which discriminates either regularly or irregularly[1]. Fat is stained by alkannin only. In the first class may be placed all the aniline colours and most of the solutions of carmine, also several other colouring matters less known. This class is comparatively useless for investigation, and all, save carmine, can be used only when it is desirable to keep structures from disappearing entirely from view, as when they are mounted in some terebinthinate, such as balsam, dammar, colophonium, sandarak, chian, &c. &c. But as all these vehicles are quite incompatible with the more delicate demonstrations, I have quite discarded them, and with them all the stains belonging to the first class, almost including carmine. This last substance is so uncertain, so liable to capricious alteration, and its action really so crude, that I regard it as very little better than aniline. Moreover, to be successful, the staining must be very prolonged in a very dilute solution, a maceration which sections of fresh and delicate structures cannot be submitted to with safety. For such as have been hardened it is all very well.

The second class of stains are such as have ready power of discriminating between nucleus and corpuscle—a power which is dependent on their different behaviour in the presence of an acid or an alkaline solution. Carmine shows this difference to a limited extent, for though in an excess of acid it becomes in great measure insoluble, especially in the presence of acetic acid, yet it does not become so entirely, and therefore it is that I have never yet succeeded, nor have I met with any one else who has succeeded, in obtaining a permanently successful injection with Dr Beale's acid solution of carmine. In the presence of the most minute portion of free alkali carmine is

[1] Gold stains so irregularly as to be useless. Silver nitrate is also somewhat irregular, but silver lactate is almost perfect in marking intercellular divisions.

readily diffused, therefore for successful injection it must be in a state of absolute insolubility, as in Davies' formula.

The investigation of this point has led me to the conclusion, wherein I differ from most observers, that the nucleus of the corpuscle is faintly more alkaline than the body of the cell, the general view, originating I think with Dr Beale, being that the nucleus is more acid than the body of the corpuscle[1]. My first observation in support of this was, that an ammoniated solution of carmine stained much more differentially when the ammonia was neutralized by hydrochloric acid, and the acid added in such slight excess that a drop of litmus solution became slowly decolorised. I found that this was the secret of all the staining processes, and I could predict the results of any new colouring matter, just as I found it having a different behaviour with acid and alkali; and I further found that the more delicate this behaviour the more delicate and beautiful were the results. Therefore, the best stains are litmus and red-cabbage, but they are the most difficult to work with. Hæmatoxyllin is very good, but it is not adapted for the finest work, and in the solutions of Klein and Kleinenberg it is very rough. The former adds a quantity of alum, which makes the solution soon deteriorate, and it is very erratic in its results, whilst the solution of Dr Kleinenberg, containing calcium chloride and alum, seems to me to destroy the sections.

My own experiments with logwood have been made with the ordinary extract sold by the druggists, and the crystalline hæmatoxyllin prepared by Eidenbenz of Dresden. Of the former I made a strong watery solution with the aid of heat, filtered it, and added to it when cold about 10 per cent. of pure spirit, or a drop of oil of cloves, to make it keep. A few drops of this poured on to a fresh section will stain it a pale brown in a few minutes, and the addition of a few drops of a ·004 per cent. solution of nitric acid in distilled water will display the nuclei of a faint brown colour, whilst the rest of the tissue becomes a cherry-red. This is due to the fact that the faintly

[1] Dr Beale seems to think that the acid is set free after death, and that more is set free in the nucleus than in the surrounding bioplasm, and more in the nucleolus than in the nucleus. This view is at once met by the fact that I have stained the nucleus of living and moving cells, on a warm stage, by my indifferent fluids.

acid solution overcomes the faint alkalinity of the tissue and alters the colour of the stain, except in the nuclei, where the greater alkalinity retains the colour, and prevents its alteration by the acid. Some practice is required not to use too much acid.

Again, if a cherry-red mixture is made by adding my standard solution of nitric acid (4 per cent.) carefully to a quantity of the solution of extract of logwood, the general tissue becomes cherry-red, whilst the nuclei restore the brown colour to the stain which enters them. The same experiment can be repeated with Klein's solution. Let a section remain in that solution till it is shrivelled, crumpled, hard, and almost black. Then place it in a watch-glass with some distilled water, and add the standard acid solution drop by drop, gently moving the section about during the process, till it begins to get limp and discoloured. Then remove it and wash it in ordinary water, and it will be found that while the nuclei retain the brilliant purple colour, the general tissue has become cherry-red or light brown. A still better result is to be obtained in this way: place a little distilled water in a watch-glass, and float on its surface about half a grain of the feathery crystals of hæmatoxyllin, then add a very small quantity of strong ammonia on the point of a thin glass rod, and stir till a brilliant purple solution is formed. In this immerse the section till it is of a deep lilac colour and wash it. It will then be found that while the tissue is lilac, the nuclei are a deep purple. This stain will be found to disappear as the ammonia evaporates; but it may be completely fixed by placing the section for a few minutes in a saturated solution of alum.

To make litmus-staining fluid I boil the powder in distilled water, filter, and add some spirit to make it keep. In this the section is allowed to remain till it is a deep blue, a minute portion of ammonia being added, if the colour is not readily taken up. The section is then placed in a large quantity of distilled water, and a drop of the nitric acid solution is added. The moment the section begins to get red it must be removed and placed in some filtered tap-water; and if the process be successful, the nuclei will be seen to be a bright blue, and the general tissue a pale pink. This process wants a great deal of care and practice; but those who have the patience to wade through failures will be rewarded by the results.

My experiments with the red-cabbage stain have not yet been numerous, and not complete; but the results of some of them have been brilliant, though whether they are permanent or not I cannot say. At any rate they perfectly confirm my view that the nucleus is alkaline.

I make a solution of the colouring matter of the leaves of the red-cabbage by parboiling them in a glass vessel, or by extracting the colour by proof spirit. If the leaves be completely boiled the colour is greatly deteriorated. The addition of a little ammonia turns it into a brilliant emerald-green, which is readily taken up by sections, and careful treatment by acid restores the purple colour to the tissue, but leaves the nuclei prominent by their vivid green colour[1]. I have found that there are many other vegetable colours which give similar reactions, and which may therefore probably be of use for staining.

I mount everything in glycerine jelly, for I find that every medium, except glycerine, distorts, contracts or dims the tissues. Thus nucleated corpuscles stained by litmus, which are prominent when mounted in glycerine, become hazy, indistinct, or even wholly invisible when mounted in a terebinthinate. A section mounted in glycerine and surrounded by a varnished ring is never safe; but in glycerine jelly, with the same ring, it is as safe as in balsam; and if a little oil of cloves has been added to the jelly, just enough to make it taste of the spice, it will be perfectly secure from confervoid growth.

[1] If further proof of this alkalinity of the tissue were required, I might point to the curious facts seen on injecting Seitel's Berlin blue. When a size injection, coloured with this material, is made, the colour disappears in great measure, and to the unpractised eye the injection may seem a failure. But immersion of the tissue for a few hours in a slightly acid solution will reproduce the colour in its fullest intensity. The colour may always be destroyed by the addition of a very slight excess of alkali and restored by excess of acid.

Again we know that cell-life, as in spermatozoa, is quite destroyed by a faint excess of acid.

NOTE ON THE CONSTRUCTION AND ARRANGEMENT OF ANATOMICAL MUSEUMS. By W. H. Flower, F.R.S. *Conservator of the Museum of the Royal College of Surgeons of England.*

The Museum of the Royal College of Surgeons, in Lincoln's Inn Fields, is considered by many to be a model of good construction and arrangement, and its general plan has been more or less closely followed in most of the buildings for similar purposes which have been erected in this country during the last half century, notably those in connection with our medical schools. No doubt the general effect of the interior of the rooms is very striking, and to the casual visitor, who can take in almost at one glance a general view of the whole collection with an evenly distributed light, it appears to great advantage.

The defects in detail are only seen by persons who make a serious and systematic study of any portion of the contents, and most of all by those whose duty it is to arrange those contents in the manner best calculated to afford information to students. More than twelve years experience in the last-named occupation having gradually forced upon me the conviction of the seriousness of some of these defects, I think it desirable to point them out as a warning to those who are contemplating, as at Edinburgh and Manchester, the erection of buildings similar in purpose and general design.

The Museum of the College of Surgeons is entirely lighted from above, at the junction of the walls and the ceiling, and, consequently, the whole of the wall-surface, rendered accessible by two galleries, is available for the exhibition of specimens. All round the ground-floor this is fitted with enclosed glass cases, but in both galleries with open shelves, from nine to twelve inches deep, and only calculated to carry specimens in bottles. The consequence of this arrangement is that every department of the collection has to be subdivided throughout, according as the specimens are of a nature requiring their preservation in bottles or are more suitable for glass cases. It results from this that if any one wishes to examine, for instance, the series of diseases of bone, or any subdivision of that series, say, examples of necrosis of a particular bone, he will have to look for some of the specimens in the gallery, for others in the cases on the ground-floor, and if there should be a cast or a drawing to illustrate any of the specimens, it will have to be sought in quite a different part of the building; so that to get a connected view of any subject in systematic order, he must perpetually travel from one part of the museum to another, and still has no opportunity of directly comparing objects which must necessarily throw much light upon each other. Even, in the admirable catalogue of pathological specimens, drawn up by Sir James Paget, the necessity of following the exigencies of the faulty construction of the building caused the specimens to be primarily divided into those preserved in bottles, and those preserved in a dry state! The same observations apply with equal force to the physiological, teratological, and other series.

As a contrast to this arrangement, that of the Museum of the University of Bologna appears to great advantage. The large collection of human and comparative anatomy, teratology and pathology has recently been removed to a building, which without any architectural display, either without or within, being in fact nothing more than a disused hospital, is admirably adapted for its purpose. It consists of about twenty rooms of moderate size on one floor, and all freely communicating with each other, lighted by large windows occupying nearly the whole of one side, the other three sides being furnished with glazed wall-cases, about two feet three inches in depth (from before backwards). These cases are fitted internally with moveable shelves and racks of various sizes, upon which are arranged either bottles, dried preparations, or bones, casts or models, while drawings can be hung at the back of the case, so that each subject can be completely illustrated in one spot. Thus, in teratology, a model or drawing of the object before dissection, the dried skeleton, and the various soft parts, preserved in spirit, would be placed all together in one shelf; in the same way the history of pathological phenomena would be shewn in connection, the cast or model of the part before and after operation, with the specimen removed, in spirit or dry, as the case might be. In Comparative Anatomy also, instead of having a multiple series, as with our Museum, the illustrations of each department, whether wet or dry, are retained in juxtaposition.

The number and comparative smallness of the rooms has the advantage of keeping the different subjects illustrated by the preparations, more distinct from each other than in our system, but on the other hand it has the disadvantage of rendering the necessary surveillance of visitors by the officials of the establishment less convenient and more costly than in large rooms, and also of presenting a far less imposing *coup d'œil.*

It would, however, be quite possible to apply the chief advantage of this system of arrangement to the mode of general construction most in favour in this country. All that is necessary is that the traditional plan of fitting up a large part of the wall-space with narrow open shelves should be entirely discarded. Such shelves are quite unfit for the proper arrangement of the specimens constituting an anatomical collection, which when placed upon them are exposed not only to dust, but also to the too free handling of casual visitors, especially since anatomical museums have become places of general resort to a far greater degree than formerly.

The galleries should be made rather wider than they are at present, and all the wall-space in them fitted with glazed cases, uniform with those on the ground-floor, about two feet from before backward. The doors may be made to slide, instead of opening outwards, if the space in front of them is limited. Plate-glass shelves or open iron racks are very preferable to opaque wooden shelves where the light comes from above, but with a side light, as in the Bologna Museum, they are not so necessary.

Of course the cost of enclosing the whole of the wall-space with glass will be considerable, but when it is recognised as an indispensable condition in the perfection of a Museum, this will be provided for in the original estimate; and if funds are deficient, it would be far better to wait till they are forthcoming, or to make a smaller building thoroughly efficient for its purpose, than a larger one with radical and often irremediable defects. Moreover, a considerable saving will be effected in the future expence of the Museum, as a large number of bottles and separate glass shades now needed to protect dry specimens standing on the shelves will no longer be required, and the ever-recurring cost and trouble of dusting will be very much lessened.

LOPSIDED GENERATIONS. By Dr Hollis.

The question why we use our right-hand in preference to our left will occasionally force itself upon the minds of thinking men, and the answer is and always must be unsatisfactory. The origin of dexterity or 'right-handedness' is lost in antiquity. The earliest biblical records bear testimony to its prevalence among mankind at the date of their authorship. We read that Joseph, for instance, expressed his displeasure when Ephraim, the younger son, was touched by Israel's right-hand, and Manasseh, the elder, by his left[1]. In a later book there is a striking passage, showing the superiority of the right-hand among the semitic races over the left[2]. The ancient stone sculptures which have been handed down to us afford further, although indirect, evidence of this fact. One of the oldest of these is the false door of the tomb of Teta, at Gizeh, which dates back 2200 years before Christ. On this door we find carved stone figures holding their right-hands across their breasts in an attitude of supplication whilst their left are hanging loosely by their sides. In the ancient bas-reliefs of the Assyrians, the soldiers are always depicted as using their right-hands for all the more important manipulations with the sword and other weapons. The Kouyunjik gallery of the British Museum, with which the name of Layard will always be associated, contains many proofs of this prevalence of right-handedness, notably in the carvings illustrative of the battle between Assur-Bani-Pal and the Susians. Other eastern nations bear important testimony to the supremacy of the right-hand at a very early date. Upon a fragment of the bas-relief of the great temple Angkor Wat in Eastern Siam, illustrating the great epic, Ramayana, and preserved in an engraving by Mr Frank Vincent[3], the

[1] Genesis xlviii. 13.

[2] Judges iii. 15 and iii. 21. Compare the Ethiopian የማን, the Hebrew יָמִין, 'yamin,' the right hand. The word 'yamin' in Arabic also signifies an oath. Cf. Tattam, *Lexicon Egyptiaco-Latinum*, 1835.

[3] *Land of the White Elephant*, 1873, p. 218.

warriors hold their weapons in their right-hands. M. Mouhot considers that "some of the oldest parts of Angkor may be fixed at more than 2000 years ago, and the more recent portions not much later." Again, at Mundore there are very ancient rock-sculptures of figures holding their weapons in their right-hands[1]. It is not surprising under these circumstances to find the Sanskrit, the language of Ramayana, the epic poem of ancient India, has a word to signify 'left-handedness'. Indeed the word वाम, 'left,' meant frequently 'crooked, contrary, inverted', the French 'gauche'[2]. We thus have internal evidence from the language itself of the probable superiority of the right-hand. There are many proofs that the ancient Greeks at a very early period were right-handed. On a terra-cotta dish belonging to the Greek archaic period[3], and preserved in the British Museum, Menelaos and Hector are depicted as fighting over the body of Euphorbus. Each hero is holding a spear in his right-hand. Again, we have internal evidence from the language itself. Mancussetus illustrates my meaning clearly, when he says, *ἐκαλοῦν ἀλλήλους ἀπὸ τῶν ἀτυχηματων ὁ ἀριστερόχειρ, ὁ παραβλώψ*[4]. The metaphorical use of *δεξιός* as given by Pindar[5] and other writers confirms the hypothesis of the prevalence of dexterity in ancient Greece. On the other hand, Sophocles, in the phrase *φρενόθεν ἐπ' ἀριστερὰ ἔβας*[6] signifies by 'left' a meaning closely allied to the French *gauche*, 'clumsy'.

It will be scarcely necessary to state that all modern nations are dexterous, although Horne Tooke[7] writes, "I remember to have read in a voyage of De Gama's to Kalekut (the first made by the Portuguese round Africa), that the people of Melinda, a polished and flourishing people, were all left-handed." This statement requires further confirmation, which it, as yet, has not obtained. All modern languages (as far as I can ascertain) have words to signify 'left-handed'. The Hindoo 'khabba,

[1] Tod's *Annals of Rajast'han*, I. 728.
[2] *Sabda Sandherbha Sindhu.*
[3] About B.C. 700 to B.C. 500.
[4] Synes. p. 160 B.
[5] *δεξιὸν νόῳ ἀντίπαλον*, *Isth.* v. 61 (Donaldson). Cf. Thuc. III. 82. *ζητῶν δεξιὸς εἶναι*, Aristoph. *Nubes*, 428.
[6] *Ajax*, 188.
[7] *Diversions of Purley*, II. cap. I.

labra', the Arab 'usrawi', the Turkish 'sòlàk' mean the same. The Russian 'Lyvpia', the German 'das linksseyn' and the French 'gaucher' are closely synonymous. A left-handed person in China is said to be "yung tso show tĕĭh," whilst the Copts and Armenians have each a single word to express 'left-handedness'. The Italian 'mancino', 'left-handed', is derived from 'mancus', 'maimed'; this word however originally meant 'left', as the following quotation from Domitius Ulpianus will shew: "Sciendum, scævam non esse morbosum, præterquam si, imbecillitate dextræ, validius sinistra utatur: sed hunc non scævam, sed mancum esse dicimus[1]." In the above phrase 'mancus' clearly means 'scæva', a 'left-handed' person and something more. Lastly, in close relation to the Latin 'sinister', both by derivation and in meaning, is the Saxon 'winstre', Danish 'venstre', Swedish 'wänster', Icelandic 'vinstri'. Our own 'left-hand' is that which is 'leaved' or 'left' when only one hand of the two is to be employed[2]. I need not here multiply instances of the universal prevalence of dexterity amongst civilised nations of the present generation, as the fact is too well known to require further support.

The failure to ascertain the origin of 'right-handedness' in post-historic times will lead us to search elsewhere for some clue to its primitive introduction amongst mankind. Under these circumstances let us turn our attention to the anatomical mechanism of the human body, and enquire whether there be any peculiar arrangement in its internal parts, which would explain this onesided application of our two hands. In doing so we must carefully eliminate, by a reference to comparative anatomy, such organic details as fail to throw light upon the subject from others which can be made available for the purpose.

The larger number of our organs are in duplicate, and even such as are single in man have frequently traces of such duplicate formation (*e.g.* the nose, heart, brain and liver). In a paper of this popular kind it will be unnecessary to examine this subject in all its bearings, and it will be sufficient for us to know that our right lung, kidney, liver-lobe, and limbs exceed

[1] *Dig.* 21. 1. 12.
[2] See Richardson's *Dictionary* under the word 'Left.'

in size those on the left side. This increased size of the right organs implies both a greater amount of tissue-structures in their composition, and also a larger supply of nerves and blood-vessels for their nutrition. It is a well-ascertained fact, that a man overtaken by a dense fog whilst walking on a common or other open plot of ground, invariably figures with his footsteps the segment of a circle. The direction he takes is to the left, if he be right-handed, and is fixed by the circumstance that the right leg naturally takes a somewhat longer stride than the left. In the ordinary course of life our eyes unconsciously guide and regulate the length of our footsteps and enable us to walk in a straight line. This increased length of the right stride is probably due to a greater amount of muscular development in the lower limb on that side, and to an increased activity in its contraction. It frequently happens among blacksmiths and others accustomed to wield heavy hammers with their right-hands, that the greater muscularity of the limb causes the shoulder on this side to be considerably higher than upon the other side, and gives such a man the appearance (when stripped of his clothes) of having a lateral curvature of the spine. The increased size of the right arm is in such a case palpably due to the greater amount of work it undertakes, and we might be disposed to fancy without deeper investigations that dexterity, acting in accordance with the laws of natural selection, has gradually brought about the enlargement of viscera on the right side of the body, as is shewn by anatomy—the reverse process is probably nearer the truth, as I shall presently shew.

Dexterity appears, as far as my observations go, to be confined to the human race. The monkey tribes, the present representatives of our Simian ancestry (if such they may be), use their right and left limbs indiscriminately to grasp any object offered to them. I have tried experiments with specimens of the Rhesus monkey, the bonnet monkey (macacus radiatus), the macacus silenus and the m. cynomologus; and I have been unable to detect, as the result of several experiments in each case, any preference for the use of the right limb. The thoracic viscera of some specimens of monkeys preserved at the Museum of the Royal College of Surgeons clearly prove that the right lungs of these animals bear about the same relations to their left as regards their volumes as do our own. The marmot again I have observed to use its left limbs as readily as its right, and yet there is a greater difference between the proportions of its right and left lungs than there is even in man, whilst in the little musk-deer the right lung is twice the capacity of the left[1]. On the other hand, a species of seal (Phoca vitulina), the zebra-wolf (Thylacinus cynocephalus) and Manatus australis appear to have lungs of about equal capacity on either side. The conclusion is, that the greater size of the right viscera, although possibly determining in some way the primæval selection of the right-hand in man, does not necessarily conduce to dexterity as shewn by the actions of monkeys and other animals.

Dexterity is palpably confined to the higher and more elaborate muscular actions of the limbs, and this is another reason why it can only be developed to any great extent in civilised man. We can grasp an object as readily with the left-hand as with the right, but most of us have experienced the awkwardness of attempting to use a pen or hurl a ball with the left-hand. The cause of this peculiarity in man must be sought in that part of his system, wherein he manifestly excels the lower animals, and that is the brain. No other animal can so arrange and modify the various muscles in a part of its body, as to thread a needle, or to articulate a rapidly following intelligible series of words, for such sounds are produced by the careful mutual adjustment of numerous muscular actions.

The left side of the brain in mankind is larger than the right[2], and it is this side which through a decussation or crossing of its fibres at the upper part of the spinal marrow supplies the right side of the body with volitional powers. The investigations of pathologists, confirmed to a great extent by some recent physiological experiments, have shewn that the power of articulation in the right-handed is confined to a certain convo-

[1] Mivart's *Anatomy*, p. 464. The right lung and kidney of the horse are larger than the left. Chauveau et Arloing, *Anat. Comp.* 1871, p. 515.

[2] The left hemisphere of the brain is 'much larger than the right side.' Brown-Séquard, Tonar Lecture, delivered at Washington, April 22, 1874. *Medical and Surgical Reporter.* See also *Brit. Med. Journ.* 1874, Vol. II. p. 16. Ecker in his work on the Human Brain (translated by Galton, 1873), invariably figures the left side somewhat larger than the right, *e.g.* fig. 2, p. 12 and fig. 3, p. 24.

lution on the left side of the brain. We thus arrive at the curious fact, that in speaking and thinking (for we mostly think in words) we use the left side of our brain to the exclusion of the right, just as we do when we write or throw a ball. I believe that I can shew how unfair to ourselves and to others is this result of dextral education.

Medical men of late years have had their attention frequently directed towards certain peculiar brain-affections implicating the powers of speech. A man whose intellectual powers are otherwise apparently unaffected may suddenly be attacked by a disease called 'amnesia', in which he loses his memory of words, or by 'aphasia', and finds that although he remembers the words, he cannot utter them. In such cases we now know that such a man, if he be 'right-handed', suffers from a lesion affecting the articulatory convolution of the left side of his brain before mentioned. On the other hand, however, should the patient be left-handed, a corresponding spot upon the right side of the brain is diseased[1].

Further, we have the statements of two eminent physiologists[2] to the effect that such aphasic lesions can be recovered from by exercising the opposite side of the brain for articulatory purposes. The gradual return of the powers of speech in such cases is frequently observed; if, therefore, we admit this explanation of their recovery, and I think that it is the only probable one, the inference is, that had these patients from their childhood upwards utilized both sides of their brain equally, the disease would not have occurred when it did. Closely allied to this disease is the hammer-palsy, observed, according to Mr. W. Frank Smith, to affect knife-forgers and other hammermen. It consists of more or less loss of power over the right limbs, combined occasionally with symptoms of aphasia. A penknife-forger frequently delivers as many as 28,800 accurate strokes with his hammer in the course of a day[3]. "The rapidity and accuracy with which these blows rain upon the slender piece of iron is wonderful to the onlooker. Supposing him to

[1] Brown-Séquard, Tonar Lecture delivered at Washington (*Med. and Surg. Rep.* April, 1874); Broadbent, *Med. Chir. Trans.* LV. p. 173 and others.

[2] Brown-Séquard, *ibid.*; Ferrier, Abstract of paper in West Riding Lunatic Asylum Reports (*Journ. of Anat.* VIII. p. 154).

[3] *Brit. Med. Journ.* Oct. 31, 1874, p. 552.

work three hundred days in a year, and to continue this for ten years, he will in that period have delivered eighty-eight million four hundred thousand strokes; and just so many discharges of nerve-force will have occurred in the motor ganglia which are engaged in the action, and in the higher ganglia which calculate the distance and judge of the amount of force necessary to be evolved." The palsy, which occasionally follows this excessive wear and tear of nerve-tissue in hammermen, is still more frequently seen as a result of much writing. The scrivener's palsy or writer's cramp, as the disease is called, consists in a gradual loss of prehensile power, and in a subsequent wasting of the muscles of the right arm and hand. The clerk, who is affected by this paralysis, finds an increasing difficulty in holding the pen, until he eventually becomes quite unable to do so. In the earlier stages of the ailment to abstain from writing for a few weeks will effect a cure; not so, however, when the wasting of the paralysed muscles has commenced; the disease is then incurable as far as the right-hand is concerned. There are still hopes for the patient, however, if he learns to write with his left-hand he may continue his previous employment[1]. We cannot doubt that had such a person from his childhood learnt to write readily with either hand, the paralytic seizure would have been postponed.

That many worthy lives have fallen a sacrifice to this Moloch of education is undoubtedly true. A few weeks ago Dr John Ogle, in a most interesting lecture[2], drew attention to the fact that Dr Samuel Johnson suffered from aphasia before his death. Writing to Mrs Thrale two days after his attack, the great lexicographer observed, "I perceived that I had suffered from a paralytic stroke, and that my speech was taken from me. I had no pain and so little dejection, in this dreadful state, that I wondered at my own apathy, and considered that perhaps *death itself* when it should come, would excite less horror than seems now to attend it." He goes on to state that he wrote a card to Mr Allen that he might have "a discreet

[1] For an interesting case of this kind see Dr Poore's paper on 'Writer's Cramp,' *Practitioner*, Aug. 1873, p. 97.

[2] *Brit. Med. Journ.* 1874, II. p. 163. The quotations are from Boswell's *Life of Johnson.*

friend at hand, to act as occasion should require." "In penning this note, I had some difficulty: my hand, I know not how or why, *made wrong letters.*" Johnson did not die of this attack, but he appears never to have recovered the full use of his mental powers. His death took place about a year subsequently. Dean Swift is another instance according to the same authority of this disease, he[1] "sometimes would try evidently with pain to find words, but not being able, he would fetch a sigh and remain silent." Upon one occasion when a servant was breaking a large coal, he said, "That is a stone, you blockhead." These were the last words he uttered. He died about a year subsequently[2]. In a bust or cast taken after death, as well as one taken during life, there were indications of paralysis of the right side of the face; Swift had, however, palsy of the left limbs also. Spalding, the eminent German scholar, is also mentioned by Dr Ogle, as having suffered from aphasia. Dr Milligan, in his book *On the Passions,* quoting the *Psychological Magazine,* mentions this case as it is recorded by himself. It appears that his mind had for some time been overtaxed, when, on the occasion of his writing a receipt for some money, "as soon as he had written the first few words, he found himself incapable of proceeding further. He strove all he could and strained his attention to the uttermost but to no purpose. He knew the characters he continued to make were not those he wished to write, but could not discover where the fault lay. He then desisted, and partly by gestures made the person who waited for the receipt understand that he should leave him. For about half-an-hour a tumultuary disorder reigned in his senses, so that he was incapable of remarking any thing very particular, except that one series of ideas of a trifling nature and confusedly intermixed, forced themselves involuntarily on the mind. At the same time, his external senses continued perfect, and he saw and knew every thing around him. His speech, however, failed in the same manner as his power of writing, and he perceived that *he spoke other words than those he intended.* In less than an hour he recovered him-

[1] Some particulars concerning Swift and Stella, *Dubl. Quart. Journ. of Med. Science*, III. 381.

[2] *A new and general Biographical Dictionary*, London, 1798, article, 'Swift.'

self from his confusion and felt nothing but a slight headache. On examining the receipt on which the aberration first betrayed itself, he found that instead of the words 'fifty dollars,' he had written 'fifty dollars through the salvation of Bra—;' the last word being left unfinished and without his having the least recollection of what it was intended to be." Such cases as these, to the exclusion of many others which might be adduced, shew how active energetic brains break down by overwork, or rather by ill-balanced work. It is perhaps too much to say, that none of these attacks would have taken place had the patients allowed each side of their brains to participate equally in their work, but speaking with some reservation, I believe it is probable that the disease would have been indefinitely postponed had their education been other than 'lopsided'. Physicians have long since learnt to educate each eye and each ear equally to aid them in the diagnosis of disease, and as workers at the microscope or stethoscope they can testify to the relief which is given to a wearied organ by employing for a while its fellow. Why should we not thus educate our hands?

In the days of our forefathers when work was not performed at the present high-pressure speed, and the struggle for existence was proportionately less, the dextral flaw in our education was of little or no importance; now, however, the time has arrived when our posterity must utilize to the utmost every cubic line of brain-substance, and this can only be done by a system of education which will enforce an equal prominence to both sides of the brain in all intellectual operations. Our visage must no longer be as the "semihominis Caci facies[1]", and our bodies cannot for the future assimilate with those 'half-men' of Zulu story, who "found a Zulu maid in a cave and thought she was two people, but on closer inspection of her admitted, 'The thing is pretty! But oh the two legs[2]!'" Let us for the future change Horne Tooke's definition of the *left-hand* as "that which we are taught to *leave out* of use when one hand only is employed[3]," into "that which is *left* for us to use when the right-hand is wearied by continued work."

[1] Virg. *Æn.* VIII. 194. [2] Tylor's *Primitive Culture*, I. p. 353.
[3] *Opus citat.* II. p. 10.

OBSERVATIONS ON THE DEVELOPMENT AND STRUCTURE OF THE KIDNEY. By WALTER PYE, *London.* (Pl. III.).

I.

RIEDEL[1], who has lately investigated the mode of development of the kidney, concludes that the Malpighian capsule and glomerulus originate in a somewhat complicated manner. His account differs considerably from the original one of Remak, who described the capsule as formed by the dilated peripheral end of a urinary tubule becoming invaginated by the embryonic vascular tuft.

Riedel's conclusions may be summarized as follows:—

(a) The collecting tubules and these alone are developed as outgrowths from the ureters. (b) These tubules divide and subdivide in the substance of the kidney and end at the periphery in dilated ampullæ. (c) To these dilatations there is applied a round cellular mass, developed from the indifferent tissue between the tubules, which is connected with the capsule of the kidney, and grows by proliferation. (d) By a process of fission part of this mass becomes developed into the glomerulus, while the rest goes to form the Bowman's Capsule; thus between these parts a cavity is established. (e) The part which forms the capsule becomes applied to the collecting tubule by a short stalk, and subsequently the cavity becomes continuous with the lumen of the tube. (f) Ultimately the stalk developes into the tubuli contorti and loops of Henle.

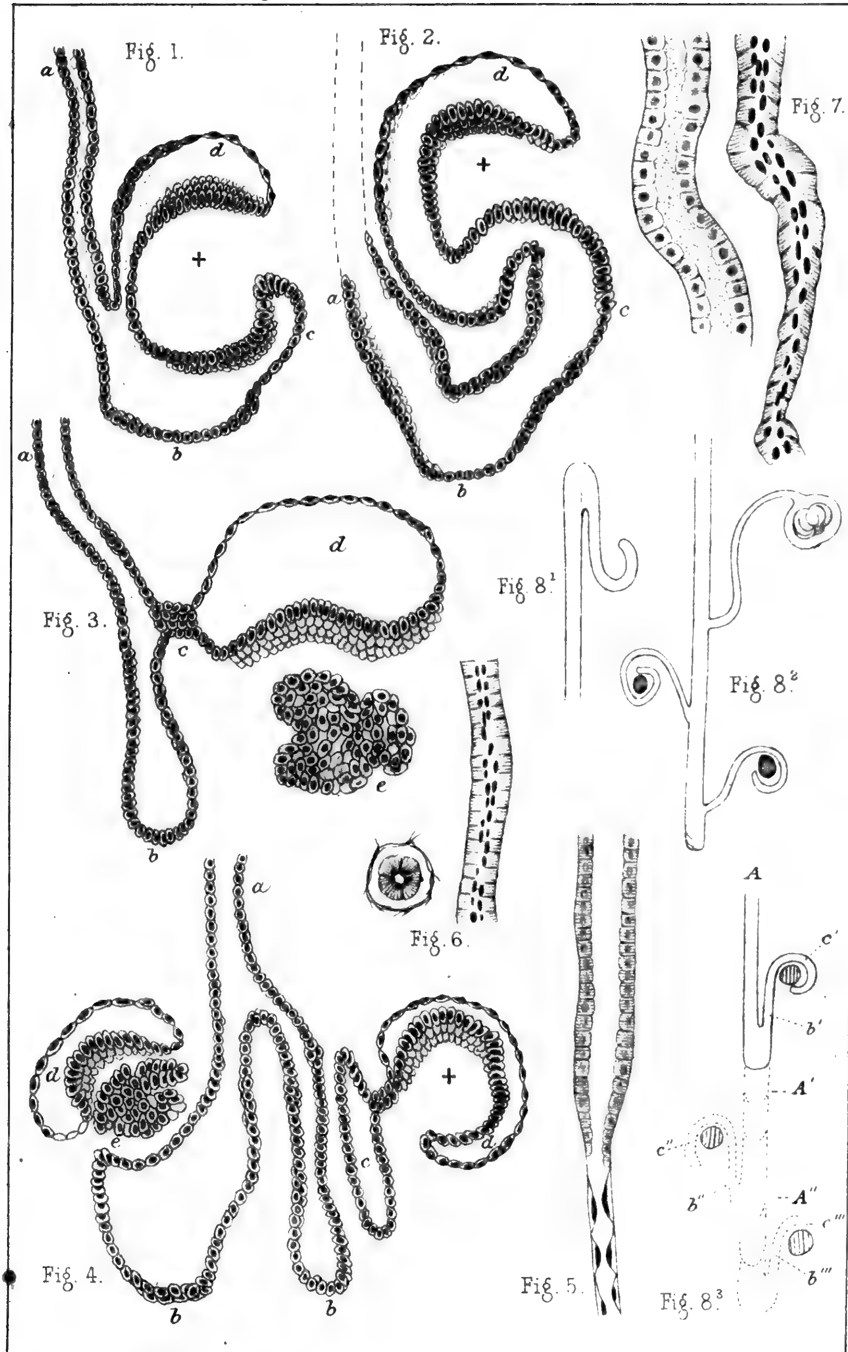
It follows from this account that the Malpighian capsules, tubuli contorti and loops of Henle are all developed, according to Riedel, from the embryonal tissue between the collecting tubes, not as prolongations of such tubes.

As to the character of the epithelium of the capsule, the existence in the adult of a delicate layer of cells, closely investing each division of the glomerulus, and dipping down between each of these divisions, has now been established by the researches of Heidenhain and others. In the fœtus it has long been recognized that the glomerulus is covered with a layer of spheroidal cells, the cells lining the capsule being in addition more prominent than in the adult.

Victor Seng[2] has given a detailed account of this epithelium. In the kidneys of the fœtal pig, dog, and man, he states that both the

[1] "*Entwickelung der Säugethierniere,*" *Untersuchungen aus dem Anatomischen Institut zu Rostock*, 1874.

[2] Aus dem LXIV. Bande der *Sitzb. der k. Akad. Wissensch.* 11 Abth. Oct. Heft. 1871.



W. Pye, del^t

M^c Farlane & Erskine, Lith^rs Edin^r

DEVELOPMENT OF KIDNEY.

outside of the glomerulus and the inside of the capsule are lined at first with embryonic round nucleated cells, and that further development results in a transformation of the capsular cells into a single layer of flattened nucleated ones, while those covering the glomerulus remain polyhedral for a longer period.

I have recently examined the kidney of a human fœtus (at about the 4th month) in which the structural characters were shown exceedingly well.

This kidney was simply hardened in spirit and sections were made in directions at right angles to each other. There was no difference in the appearance presented by the two sets of sections in the points to which I directed my attention.

The conclusions I have come to with regard to the mode of formation of the Malpighian capsules differ in many respects from those of Riedel, and I hope to show that the process of development he describes was probably suggested by sections made somewhat obliquely to the axis of the tubule and capsule. A section made through the whole thickness of the kidney from papilla to cortex, if stained with hæmatoxylin, will show, when examined with the microscope under a low power, a number of straight tubules running from papilla to periphery, diverging in their course, and branching dichotomously at acute angles. At the periphery they will be seen to be in connection with Malpighian capsules in process of formation, but the manner of this connection can only be well seen under a high power (not lower than an objective No. 7 of Hartnack).

These tubules, from their commencement in the papilla to their termination close to the edge of the kidney, are evidently those prolongations of the ureter, which become collecting tubules, for they are sharply distinguished from the large convoluted tubes among which they lie, by their straightness, their small diameter, and the character of their epithelium, which is small, sharply defined, and deeply stained by the hæmatoxylin.

On examining the peripheric end of one of these tubes cut in the direction of its long axis, with an objective No. 7 or 8 of Hartnack, it will be seen to be in connection with the capsule of the glomerulus in the following rather complicated manner.

The tube, lined with spheroidal nucleated cells, ascends through the cortex to within a short distance of the kidney capsule and is there greatly enlarged. This enlargement is effected by one side of the tube being continued for a short but variable distance in its original direction, while the other is turned somewhat abruptly on itself. The first side then turns and runs parallel to its fellow (see Fig. II.) back into the depths of the kidney.

The effect of the arrangement thus diagrammatically stated is, that the tube presents a budlike projection towards the free surface of the kidney and then turns to form what I will call the descending limb. This limb, which is short and tortuous, ends by curving round the embryonic glomerulus so as to embrace it, and thus becomes its capsule. Here, as described by Seng, the epithelium of one side of the tube becomes flattened out, while that of the other side, which is applied closely to the glomerulus, consists of one or more layers of deeply stained cells, whose shapes vary from nearly round to nearly columnar. (See Figs. I. II.)

Out of many sections I have only found one doubtful case, in which the tube ended in an enlarged blind extremity, of which the apex appeared to be inflected, so as to form a covering for the developing glomerulus in the manner described by Remak. Therefore, though this method of formation may sometimes occur, it certainly is not common.

The descending limb, in addition to being more or less tortuous, frequently has the plane of its axis at a considerable angle from that of the tube itself. It will then easily be understood that unless the axis of the collecting tube and its descending limb, are in the same, or nearly the same, plane, and the section is also made in that plane, part of the limb between the tube and the capsule of the glomerulus will be cut away, and the latter will appear to be placed by the side of the former but quite separate from it. (See Fig. IV.)

This arrangement, modified in various degrees, is presented by the great majority of instances, whilst only in a small number is it possible to see the continuity of the collecting tube and descending limb. An independent origin of the Bowman's capsule, therefore, is likely to be suggested by the usual appearances presented. This probably will account for Riedel's description of the mode of development.

The budlike projection at the peripheral part of the tube appears to be the point at which it grows in length with the growth of the kidney; for it hardly exists in those tubes which are close to the periphery, and have a simple arrangement of the parts going to form the Bowman's capsule, that is in those tubes in which this capsule has only just begun to be formed. (Fig. I.) Whilst on the other hand it is long in those tubes where the glomerulus and capsule are at some distance from the edge of the cortex, and are, therefore, of earlier formation. (See Fig. III.)

If in Fig. VIII. A represent the collecting tubule with A', A'' its further growth from the budlike projection, while b', b'', b''' and c', c'', c''' represent the descending limbs and their termination enveloping the glomerulus d, the parts b', b'' of the descending limb will correspond to the stalk, connecting the Bowman's capsule with the collecting tube, which Riedel describes, and which he states becomes subsequently developed into convoluted tubes and loops of Henle.

The Bowman's capsules are generally formed in pairs, being placed one on each tube just after a dichotomous division. They are generally back to back. (Fig. IV.)

This arrangement may be seen not only in the neighbourhood of the kidney-capsule, but also in the depth of the kidney, though there it is not so frequent, the development of the convoluted tubes naturally soon causing a disturbance of the original symmetrical arrangement.

With regard to the epithelial covering of the capsule and its glomerulus the appearances are exactly those which Victor Seng has figured. I have only further to state, that up to a certain point I have been able to trace very distinctly the manner in which the cellular investment of the glomerulus, which at first spreads uniformly over the whole mass of the embryonic vessels, gradually dips down between the subdivisions of the vascular tuft, as those divisions become more perfectly differentiated.

II.

Ludwig[1], in his account of the structure of the kidney tubules, summarizes their division as follows :—(1) Primary convoluted tubes commencing as the capsules of the glomeruli. (2) Henle's loops with their descending and ascending limbs. (3) Intermediary convoluted portions which commence when the ascending limbs have regained the cortex, and which end by coalescing to form straight collecting tubules.

When describing more particularly the diameters of the various parts of these tubules, he states that the convoluted tubes suddenly narrow into the descending parts of Henle's loops. This narrow part generally occupies the descending and part of the ascending limbs, while the remainder of the latter is formed by a somewhat larger tube.

These enlarged ascending limbs then run in the medullary processes to the cortex, in which, after being slightly constricted for a short distance, they again enlarge till their diameter is equal to that of the original convoluted tubes, that is until they are converted into the intermediary convoluted ones.

The epithelium of the two convoluted parts is described by him as composed of a cloudy granular matrix, containing nuclei and presenting fissures here and there, but no regular differentiation into cells.

The loops of Henle, as long as they retain their small diameter, are lined by a layer of clear flattened cells, but when enlarged in the ascending limbs, the epithelium, while still remaining clear, is composed of separate columnar cells arranged in an imbricated manner.

According to Ludwig, therefore, the ascending limb of Henle's loops having once become enlarged, retains its size and the character of its epithelium unchanged, during its upward course through medulla and cortex, until just before it is further enlarged and becomes convoluted a second time.

It is to the characters of these ascending limbs that I wish to draw attention, and I shall endeavour to show that, from their varying diameters and the changes which their epithelium presents in different parts of their course, they may fairly be subdivided with somewhat more detail than has hitherto been done.

Heidenhain[2] describes the substance of the nucleated epithelial cells of mammalian kidney tubules (with the exception of the flattened cells of the descending parts of Henle's loops)

[1] Stricker's *Human and Comparative Histology.* Sydenham Society's Translation.

[2] *Max Schultze's Archiv*, 1878, p. 1.

as being composed of minute rods, usually arranged at right angles to the long axis of the tube.

Following a method of preparation similar to the one described by him, I became satisfied of the correctness of his statements. This method consisted in placing small bits of fresh kidney in 5 p. c. solution of chromate of ammonia for 48 hours and then in water for from 5 to 8 hours more, they were then left in spirit until they became sufficiently hard to allow of sections being made.

The rod-like nature of the substance of the epithelial cells lining the lumina of both kinds of convoluted tubes, and of the larger ascending parts of Henle's loops, may be demonstrated with great ease in the kidneys of dogs and rabbits, if prepared in the way just described.

With regard to the ascending limbs of Henle's loops, I have noticed in addition certain points which have not, I think, been fully described by previous observers. These points concern (1) their course, (2) variations in their diameter and size of lumen, (3) variations of position of the nuclei and arrangement of the rods in the cells.

Having imbedded portions of the kidney, sections were cut in planes as nearly as possible parallel to the course of the tubes in the medullary processes and medulla, and were then mounted in the usual way, after having been rather deeply stained with hæmatoxylin.

From the appearances presented by these preparations, it seems that the course of the ascending limb may be divided into four parts, each differing in size and in the character of their epithelium. These are (1) the part nearest the loop, lined with clear flattened cells, as described by Ludwig, (2) the part where the tube becomes broader, and has, as a distinctive feature, cubical epithelial cells, (3) the part placed in the medullary processes, and that part just below them, i.e. in the external part of the "intermediate portion" of Ludwig; it is distinguished from the last-named by being narrower, and by the characters of its epithelium, (4) the tubes when running in the cortex.

In Fig. v. I have drawn the end of the first and the beginning of the second divisions. With regard to the first, I have nothing to add to Ludwig's description. The second will be seen to be much the larger of the two, and to present the appearance of a straight tube possessing a large lumen, and with an epithelium composed of pale cubical cells with rather indistinct rods, and faintly marked nuclei placed near their centres.

Fig. VI. represents a horizontal and vertical section of the third division, as described above. It differs from the preceding part in the following points: Its diameter decreases throughout its whole length, the decrease being most marked at its termination in the cortex. The rods of the epithelial cells are much more distinct and are apparently coarser; and, either in the whole length of the tube (not represented in the figure), or in various parts of it, are very frequently, though I think not usually, arranged in a sloping manner. They generally appear, however, to be placed at right angles to the axis of the tube. There is very little lumen in this division of the tube, caused partly by an actual increase of the size of the cells, partly by its decrease in diameter. The nuclei of the cells are large and very distinct; they differ also from those of the second division by being all crowded towards the centre of the tube; and, lastly, the tubes, instead of being straight as before, are slightly wavy.

In Figure VII. is represented the fourth division, and, running by its side, a convoluted tube for the sake of comparison. It differs from the preceding mainly in presenting numerous angular bends and abrupt changes in diameter; where largest, its diameter may come near to that of a convoluted tube, whilst at its smallest part it is of about the same size as the cortical end of the third division.

This whole division stains deeply with hæmatoxylin, the nuclei are placed as in the previous division, and the fibrillæ are still more evident and more generally imbricated than before. On the whole, however, the difference between divisions 3 and 4 appears to be one rather of situation than structure. Placed among the convoluted tubes as the latter is, it seems to be forced into abrupt change of direction, to which, perhaps from the peculiar nature of its epithelium, or from some other cause, it accommodates itself by angular rather than by curvilinear turns.

In conclusion, I have to render my thanks to Dr Klein, under whose direction the above investigations were made.

EXPLANATION OF FIGURES.

Figs I., II. Peripheral ends of the collecting tubes with their descending limbs turning back to form capsules for the glomeruli. (The glomeruli are not figured, they were in the position *). The arrangement in Fig. I. is not quite typical, but rather unusually simple. The bend of this tube being close to the capsule of the kidney, there is no budlike projection. Fig. II. represents the usual arrangement of parts, the "bud" being present but small.

Fig. III. Collecting tube, in connection with a Bowman's capsule, at some little distance from the edge of the kidney, and having a well-marked bud-like projection below. This section not being made exactly in the axis of the capsule and descending limb, a good deal of each of these parts has been cut away, and their relations are not quite clear. Had the Section been made through the centre of the capsule and glomerulus (which is here figured), the former would have been seen to envelope the latter much more completely and closely than appears to be the case.

Fig. IV. illustrates the appearance generally presented by collecting tubes, the descending limbs of which have been cut away in consequence of the Section not passing through their long axis. In this Figure the capsule and glomerulus appear to be quite independent of the collecting tube, by the side of which they lie; there is also shown the formation of the Bowman's capsules in pairs, as described in the text.

In all these Figures the difference between the epithelial cells lining the capsule and those investing the glomerulus is shown.

References to Figures I.—IV.

a. Collecting tube.
b. Bud towards periphery of kidney.
c. Descending limb.
d. Bowman's capsule.
e. Embryonic glomerulus.

Figures V., VI., VII., VIII., described in the text.

All the drawings are made under Hartnack's No. 2 eye-piece and No. 7 objective.

A NOTE ON THE MECHANICAL WORK OF RESPIRATION. By B. Thompson Lowne, F.R.C.S., F.L.S., and Z.S., *Lecturer on Physiology at the Middlesex Hospital Medical School.*

The work of Respiration has been calculated by Professor Haughton to be equal to twenty-one foot tons per day[1]; Fick gives a very similar estimate, as he states that the work necessary for the inspiration of 600 cc. of air is equal to ·63 kilogrammeters. Dr Hutchinson, by measuring the force required to inflate the chest after death with a quantity of air equal to that contained during life, arrived at the same conclusion[2].

These estimates are quoted in Carpenter's *Human Physiology*, and are usually received, at least by students, as correct. Donders, without however criticising these results, which imply the support of a pressure about equal to two inches of mercury, remarks, that the expiratory effort in normal tranquil respiration is only capable of supporting about 3 mm. of water when the manometer is connected with one nostril, the other remaining free, although the pressure rapidly rises to several times this amount as soon as the discomfort attending the experiment is felt. In my own case so rapid is this change that the pressure rises with each successive respiration until the difference of the level of the fluid in the two limbs of the manometer attains three-quarters of an inch.

The work done during respiration is supposed by the above authorities to be chiefly done upon the elastic tissue of the lungs and the elasticity of the thoracic wall, but it is evident that any work done against elastic forces during inspiration must be done by those forces upon the air or upon muscle acting antagonistically to elasticity during expiration: hence all the work, except that which is lost by friction and the imperfection of the mechanism, is either done upon the air contained in the cavity of the thorax, or the elastic forces brought into play are too great for the work required, and are

[1] *Brit. Med. Journal*, 1868.
[2] *Med. Chir. Trans.* xxix. 205.

counteracted by absolute work done against them during both inspiration and expiration; an hypothesis which has no evidence to support it, and one which is fundamentally opposed to all that we know of the animal mechanism. No one, probably, would hold that the inspiratory muscles are in activity during the expiratory effort for the purpose of opposing the elastic force of the thoracic wall: a force which they have themselves called into play.

I shall now endeavour to shew that the work done upon the air in the cavity of the thorax is exceedingly small in comparison to the above estimates, and that the work of respiration falls very far short of the amount stated.

There can be no doubt that the elastic force exerted by the wall of the lung is considerable; Donders[1] has estimated it at 15 mm. of mercury, or about five ounces on the square inch, when the lung is fully expanded with air; Hutchinson[2] gives a still higher estimate, and mentions half-a-pound on the square inch as a maximum value. During life, moreover, something must be added to this force for the pressure due to the tone of the muscular tissue of the bronchi (Donders).

Perhaps it may not be unnecessary, in this connection, to call attention to the disposition of the elastic tissue of the lung. This, as is well known, consists of numerous fine elastic fibres, disposed in curves around or partly round the lobules, infundibula, and air-cells. When the lungs are taken from the thoracic cavity the contraction of these fibres diminishes the capacity of the lung-cavity to a very great extent; when in the thoracic cavity we may conceive the peripheral portion of every curve as fixed by the absence of atmospheric air in the pleural cavity, that is, we may consider that the elastic fibres take their origin from the interior of the thoracic wall, so that if these fibres were straight they would enlarge the lung-cavity instead of diminishing it by their contraction; as however the fibres are curved, their shortening must diminish the lung-space and act as an expiratory agent, unless they were otherwise counteracted. That the shortening of the fibres will cause the lung-walls to encroach on the air spaces, follows from the fact

[1] Donders' *Physiology*. *Henle und Pfeuffer's Zeitsch.* Bd. III. and IV.
[2] *l. c.*

that the sum of the work done by the contraction of these curved fibres must be a maximum compared with that in all other forms which the membrane that bounds the air-cells can continuously assume.

That the elastic force of the lung-tissue is counteracted by another and opposite force, follows from the comparatively small minus pressure in the pleural cavity. According to the most recent researches[1], there is no doubt that the position of the thoracic wall at the end of a normal expiratory act is one of equilibrium; no muscles are then acting, hence the thoracic parietes, probably by virtue of the tone of the inspiratory muscles and the elasticity of the rib-cartilages, tend to expand to exactly the same extent that the lungs tend to contract, and the two forces balance each other. In no other condition would there be a minus pressure in the pleural cavity and a condition of equilibrium. The minus pressure in the pleural cavity must therefore be equal to the sum of the two elastic forces, the inward tending elasticity of the lung and the outward tending elastic force of the chest-wall. This pressure has been shewn by Donders and others to equal about 6mm. of mercury, or two ounces to the square inch.

Hence it is quite clear that the elastic force of the lung-walls must be counterbalanced in part during life. For a very long time these facts puzzled me considerably, but I can easily see now that the circulation of the blood upon the walls of the lung-cells and in the pulmonary arteries must act as an opposing force to the elasticity of the lung-wall. When a fluid is contained under pressure in a series of extensile tubes it is well known that the tubes undergo elongation, hence the blood-pressure in the network of pulmonary vessels, by elongating them, and more especially by extending the meshwork of capillaries and minute arteries in the elastic lung-wall, must supply an outward tending force, which to a greater or less extent counterbalances the contracting elastic fibres of the pulmonary tissue. Experiments are however wanting to verify these conclusions, although I am convinced of their accuracy. I moreover believe that further investigation of these relations

[1] Dr Burdon Sanderson, *Handbook for the Physiological Laboratory.*

will aid the clinical investigation of some deranged conditions of the lung.

The pressure exerted upon the air in the lungs must moreover be always less than the endopleural minus pressure by the amount of outward tending force exerted by the thoracic parietes, and must vanish when the thoracic outward tending pressure equals the inward tending pressure of the lung-wall, that is, at the end of a normal expiratory act.

Hence neither the elasticity of the lung of the thoracic parietes, nor the endopleural pressure, can be of any avail to determine the mechanical work of respiration, unless we can determine their resultant in the various positions of the thoracic wall.

Again, all experiments which require the application of a manometer either to the mouth or to one of the nares, give rise to abnormal respiration, and increase the normal pressure of the air in the lung.

There is, however, another method of calculating the mechanical work of respiration, which has, I believe, been hitherto overlooked—in the relation between the velocity of moving gases and the pressure producing motion.

The general formula of this relation is well known:

$$V = k\left(\frac{H}{h+H}\right)^{\frac{1}{2}},$$

where $k = 1398$ feet, or the velocity with which gases rush into a vacuum under the pressure of an atmosphere. In this formula $h =$ the height of a column of fluid equal to an atmosphere, and H the height of a column of fluid producing the pressure causing motion. In the case of the lung during expiration, $H =$ the pressure of the thoracic wall upon the air in the lung measured by the height of a column of fluid which would be supported by an equal pressure.

When gases flow through tubes the quantity V calculated by this formula is reduced in proportion to the work done in each tube, and this work, or rather coefficient of work, $= a\frac{\sqrt{l}}{\rho}$, where $a =$ the loss of velocity in a smooth standard tube of unit length and radius, and l and ρ are the length and radius of the tube in which we wish to calculate the velocity.

Hence, to obtain the velocity V' in any given tube, we have only to divide V by this coefficient,

and
$$V' = \frac{k\sqrt{\dfrac{H}{H+h}}}{a\dfrac{\sqrt{l}}{\rho}}.$$

Numerous experiments shew that the value of a for a smooth glass or metal tube ten yards long and one inch radius = 1·3, and this coefficient is the same whatever the gas employed.

I have verified the above formulæ in the case of a tube 1·5 feet in length with a radius of $\frac{1}{10}$ of an inch, and found it absolutely correct. It is applicable to tubes of various lengths of one and three inch radius.

The above formula is also deduced from the first principles of dynamics, since

$$V = \sqrt{(2fs)},$$

and the velocity varies inversely as the negative acceleration, which equals a for every unit of length; therefore

$$V = \frac{\sqrt{(2fs)}}{a\,.\,s} = \frac{\sqrt{2f}}{a\sqrt{s}},$$

where s = the length of the tube.

Again, since the coefficient of work done in a tube is directly as its surface and inversely as its area, it varies as $\frac{1}{r}$.

In order to apply the above formulæ for the calculation of the work of respiration, it is necessary to estimate the value of V, or the velocity with which the air escapes from the trachea. I have made a series of experiments with light paper vanes to endeavour to estimate the velocity of the air as it passes from the mouth and nostrils, and from these, as well as by observations made on the apparent velocity of the watery vapour expelled, which is easily observed in frosty weather, I am sure that about eight feet a second is a very fair average. The same result may be arrived at by considering the narrowest part of the glottis to have an area of about ·25 of a square inch, the average quantity of air changed at each respiration at between 25 and 30 cubic inches, and the average duration of inspiration or expiration at a second and a quarter. These measurements are perhaps, with the exception of the last, too great, calculating from a standard tube the value of $a \frac{r}{\sqrt{l}}$ for the trachea and bronchi = 3·25 nearly, if we estimate their mean length at two feet and their mean diameter at ·2 of an inch. This correction would need to be applied to the calculation if the velocity of the current approached the velocity of the current at the aperture; but since this is a coefficient by which the velocity must be divided, it actually almost vanishes when the mean velocity of the air in the bronchial tubes, the united areas of which are many times larger than the area of the orifice, is taken into account.

In order to establish the actual loss of velocity due to friction in the glottis, I connected a larynx and trachea with a vessel containing compressed air. The pressure of the air was estimated by a manometer connected with the receiver, and the quantity expelled under this pressure, which was kept constant by a continuous supply pumped into the receiver, was measured by a meter between the pump and the receiver[1]. The quantity of air supplied to the receiver was 25 cubic inches a second, and the pressure maintained by this supply equalled ·25 of an inch of water. As the orifice of the glottis in the larynx employed measured only $\frac{5}{64}$ of a square inch, the velocity imparted to the air by this pressure at the opening of the glottis was as nearly as possible 27 feet a second. The calculated velocity for the same pressure may be set down at 37 feet a second, nearly, hence the coefficient of loss of velocity = ·73 nearly: and this correction will be a maximum correction, since the orifice was greatly contracted in the dead larynx by the approximation of the vocal cords.

In accordance with this correction we may take the actual pressure required, and give a velocity of eight feet per second as that which would theoretically give a velocity of eleven feet per second.

[1] These experiments were made in the University College Laboratory, which I was permitted to make use of by the courtesy of Dr Burdon Sanderson.

Since H is very small we may write

$$V = k\sqrt{\frac{H}{h}}$$

without sensibly affecting the result, so that we have

$$\frac{V^2}{k^2} = \frac{H}{h}; \quad \therefore \frac{121 \times 760}{1954404} = H$$

in millimeters of mercury, and a pressure of 6·5 grains, nearly, on the square inch, is the pressure required to produce the velocity in question. This pressure appears to be quite competent to give the resultant velocity if we remember that the velocity decreases so rapidly in the trachea and bronchi that the friction in these tubes can bear only a very small relation to the friction in the trachea and glottis. If, however, we take the largest possible estimate of this friction, and consider that the air in passing through a series of parallel tubes having an average diameter of $\frac{1}{5}$ of an inch, with a velocity equal to that at which it emerges from the glottis, the same calculation gives us only 68 grains pressure on the square inch.

If we take the former estimate of pressure and neglect the loss of volume due to this pressure, which is compensated for many times by increased temperature, we shall have this pressure 6·5 grains moved through a distance of 25 linear inches, however the motion may be distributed on the thoracic walls, to expel 25 cubic inches of air from the lungs; and taking 16 respirations a minute, we shall have in the inspiratory and expiratory effort 6·5 grains moved through 50 inches, which will give us

$6{\cdot}5 \times 50 = 325$ inch grains
16
$\frac{60}{12} \times 5200$ per minute
5
7000) 26,000 foot grains per hour
3·7 foot pounds „
24
148
74
88·8 foot pounds per day.

The larger estimate of work gives 936 foot pounds as the daily work of respiration, and this I am convinced is far too large an estimate, since the corrections applied are very much larger than the most probable correction.

The smoothness of the tube through which a gas is passing makes some difference in its velocity, especially when the velocity is high, but no appreciable difference with low velocities and a comparatively large area of tube, so that I think the coefficient determined by my experiment for the loss of velocity in the rima glottidis is a sufficient datum for all loss of velocity due to friction.

The foregoing calculations give us the actual external work done in moving the air during the respiratory acts for the twenty-four hours; of course a certain amount of work is done in friction in the moving parts, and this cannot be readily determined, but can only be set down as so much internal work producing heat; it is therefore done without loss to the economy. The work done in moving the abdominal viscera has likewise been neglected, but since the elastic forces, *i.e.* the tone of the muscles forming the abdominal parietes and the elastic force of the lung-wall are in equilibrium at the end of expiration, the same work, with the exception of that lost in friction, will be done by the descent of the viscera as is done upon them in raising them during the ascent of the diaphragm.

The entire work, internal and external, of respiration, will of course be some multiple of the external work, and may be expressed by the formula

$$W = \epsilon\,(1 + c),$$

where W = the entire work and ϵ the external work. The value of c in this formula will of course depend entirely on the perfection of the mechanism, and in the living organism we should scarcely expect the internal work to exceed the external work many times: that is, we should not expect the work done to be many times greater than that which would be necessary in a comparatively perfect machine.

CASE OF ATROPHY OF RIGHT HEMISPHERE OF CEREBRUM AND LEFT SIDE OF CEREBELLUM, WITH ATROPHY OF LEFT SIDE OF BODY. By JAS. C. HOWDEN, M.D., *Superintendent of the Montrose Asylum.*

S— C—. A woman, admitted into the Montrose Asylum, 6 July, 1868, æt. 30, unmarried; height 5 ft. 4½ in., weight 112 lbs., has fair hair and blue eyes. On admission, her general bodily health was good, nothing abnormal being discovered in either the circulatory, respiratory, or digestive systems, and, as far as could be ascertained, the various senses, sight, hearing, &c. were normal. Her left side is paralysed, the flexors of the fore-arm being very much contracted, drawing up, and partially closing the left hand, which is very much withered; left leg is also withered and twisted, causing her to walk on the outside of her foot.

Previous History. Her mother, who is a well-made woman, states that there was no difficulty whatever during the accouchement, no instruments being required or used. Nothing particular was noticed about the child at birth. She suckled properly, and did not shew any symptoms of being weak-minded or more irritable than children generally are. At about the age of 3 years and 9 months she commenced to have fits, up to which time she never had an accident of any kind or any severe illness. At school she was able to learn fairly, but did not shew as much ability as the average of her schoolfellows. She is stated to have had an ill-will at children, running after them and threatening to injure them when they annoyed her, but was always considered sane until shortly before her admission. There is no hereditary taint, and the principal reason for her being sent to the asylum seems to have been because the neighbours made complaints that she was dangerous to children.

September. She is at times quarrelsome and abusive, is liable when menstruating to sudden attacks of excitement, when she runs up and down the ward, but does not become convulsed in any way.

Feb. 16, 1869. On the evening of the 4th she had a regular epileptic seizure. It began at about 7 P.M. She became unconscious, fell, striking her forehead against a table, and slightly cutting her eye-brow. There was no cry, she frothed at the mouth, bit her tongue severely, and was generally convulsed, the head and arms more so however, than the lower parts of her body. The convulsions continued for 12 hours with intervals of one minute in every three or four minutes. During these intermissions however twitchings of the muscles of the neck and face were observed. Although the convulsions left her at 7 A.M. on the 5th, she continued in a state of partial stupor till the 6th. She is now well again, grumbling as formerly about what she calls the 'turns in her inside.' Her feet and legs are slightly swollen, there is no albumen in her urine.

July 1*st.* She has had no severe fit since last entry, but often has her 'turns,' which seem to be attacks of Petit Mal, after which she generally keeps her bed for a day or two, and employs her time reading her bible and complaining about her illness.

1872, *April* 30. Up to this date there has been no particular change in her condition, bodily or mentally.

May. Health feeble, often goes whole days without food. Is suffering from Phthisis.

July 21*st.* Died.

Sectio Cadaveris.

Description of Brain. On opening the Dura Mater a marked difference in size was observed between the two hemispheres; the left hemisphere was apparently normal, while the right had a small shrunken appearance. The membranes were generally opaque, and in the meshes of the Pia Mater over the right hemisphere there were numerous small blebs of fluid which occupied the place of the proper cerebral matter. These bullæ were most abundant over the right anterior lobe. On the left hemisphere there were a few small bullæ over the posterior lobe. The convolutions of the left hemisphere were normal in appearance and size.

The right hemisphere was greatly atrophied, both as regards its size generally, and that of the convolutions in the frontal, parietal and occipital lobes. Its defects in size were especially marked by its diminution in the vertical and transverse diameters. The vertical diameter of the frontal lobe was $\frac{9}{10}$ths inch: in the temporo-sphenoidal and parietal region $1\frac{8}{10}$ inch: in the occipital region $1\frac{1}{10}$ inch.

The fissure of Sylvius, owing to the great atrophy of the parietal lobe, mounted to the summit of the hemisphere in the parietal region. The fissure of Rolando was not recognisable. The parieto-occipital fissure was distinct. The several convolutions of the temporo-sphenoidal lobe could be recognized, and, except at their posterior ends, had not undergone any material diminution in size. The superior, middle, and inferior frontal convolutions were present, but only a third the size of the corresponding convolutions in the left hemisphere. The ascending frontal and parietal convolutions and the convolution of the parietal eminence could not be defined with any accuracy. The postero-parietal lobule and angular gyrus were greatly atrophied. The three occipital convolutions and the annectant gyri, though reduced in size, could be readily recognised. The convolutions of the island of Reil were well marked. The corpus callosum was greatly atrophied. In those lobes where the convolutions were atrophied on the outer surface, a corresponding atrophy had also taken place on the inner surface of the lobe.

Depending from what seemed to be the anterior inferior end of the corpus callosum were two pear-shaped pedunculated bodies, of a brownish-yellow colour, each about 15 mill. in length, and 12·5 mill. at their greatest diameter. The pedicle of the one to the right side was 5 mill.; that of the left 15 mill. in length.

The lateral ventricles of both sides were distended with fluid, the descending cornu of the right lateral ventricle being especially much dilated. At the anterior aspect of the corpus callosum was found a small gritty calcareous deposit about the size of a pea.

Cerebellum. The right lobe much larger than the left, which is small and shrivelled, especially at its centre. Superior vermiform process is of a triangular form, the angles being nearly equal. The pons is twisted, so that the median groove is more to the left side; a section of the pons shews the left side to be larger than the right. The crus on the left side is less covered by the lateral lobe of the cerebellum than on the right. The sub-peduncular lobe is small, but distinct, on the left side, and it is absent on the right. The amygdala, as indeed all other parts of the cerebellum on the left side, are small. The inferior vermiform process is compressed antero-posteriorly and twisted to the left side. The left anterior pyramid and restiform body are larger than the right.

Remarks. The interest in this case is lessened by the details of the post-mortem examination being so incomplete. The patient died when I was confined to bed by illness, and my assistant, who had just entered on his duties, took but imperfect notes, and though the brain was preserved, it was in some respects so mutilated that it could be but partially described[1]. Such as it is, however, it may be of some value for comparison with similar cases recorded by Schroeder Van der Kolk, and others. As in Van der Kolk's case the atrophied half of the cerebellum was on the opposite side to the atrophied cerebral hemisphere. The small side of the pons Varolii corresponded with the left or atrophied side of the cerebellum, while the small side of the medulla oblongata was the right, corresponding with the atrophied side of the cerebrum. Unfortunately the spinal cord was not examined. The want of symmetry of the skull externally was not such as to attract much attention, or lead to the suspicion that there was such atrophy of one half of the brain, the proportions being balanced by thickening of the skull and the presence of a large amount of serous fluid occupying the place of brain-matter. The patient could scarcely be considered insane or even imbecile. Were it not for her physical infirmities, there was no reason why she should not have earned her living. She was much deformed, being what is termed in Scotland an 'object.' The irritability and violence which led to her being placed in the asylum arose in part from epilepsy, and in part from her being

[1] The brain is preserved in the Anatomical Museum of the Edinburgh University.

a subject of ridicule, from her uncouth appearance, to young children.

The history of the case does not throw much light on the cause or duration of the atrophy. It may to a certain extent have been congenital, but some of the changes, such as the thickening of the skull, and the effusion of fluid on the atrophied side, must have gone on during the growth of the body.

I am not aware if there are any data to shew in what manner, or how rapidly, the skull thickens in cerebral atrophy. Van der Kolk thought it was only found in chronic cases. What he means by chronic he does not state, but I have certainly met with undoubted hypertrophy of the skull in cases in which there was no reason to suppose that the atrophic process had extended over more than three or four years, as in general paralysis.

For the sake of comparison I have placed my measurements side by side with those given by Van der Kolk of his case.

MEASUREMENT OF BRAIN COMPARED WITH VAN DER KOLK'S CASE.

	SMALL SIDE.		LARGE SIDE.	
	Van der Kolk.	Howden.	Van der Kolk.	Howden.
	Left mil. m.	*Right* mil. m.	*Right* mil. m.	*Left* mil. m.
Length of the Hemisphere from Anterior to Posterior lobe	136	144	163	166
Length of the Anterior lobe to fissure of Sylvius	43	35	61	53⅛
Length of the Posterior lobe to the anterior extremity of the middle lobe.........	111	112	125	125
CEREBELLUM.	*Right*	*Left*	*Left*	*Right*
Transverse diameter from the margin of the medulla oblongata to the outer edge of the Hemisphere	45	37½	52	45
MEDULLA OBLONGATA.		*Right*		*Left*
Breadth of ant. pyramid at junction with pons		5		7
Breadth of do. at middle...		5		7

OBSERVATIONS ON THE SPINY SHARK (*Echinorhinus Spinosus*). By Professor Turner.

Though the capture of several specimens of the Spiny Shark on the coasts of England has been recorded by Yarrell, Couch, and other writers on British Ichthyology, it is only within the last few years that this species of shark has been recognised as a denizen of the Scottish seas. The first naturalist to determine its presence as a Scottish species was the Rev. Professor Duns, D.D., who obtained a specimen caught at Bo'ness on the Firth of Forth, the stuffed skin of which he presented to the Museum of Science and Art, Edinburgh. A second specimen was shortly afterwards captured in the Firth, off Elie on the coast of Fife, the stuffed skin of which is preserved in the Museum of the Free Church College, Edinburgh. Dr Duns communicated a notice of the capture of these specimens to the British Association at its meeting in Edinburgh, August, 1871.

In the month of June, 1874, a female specimen of this shark, caught on the lines with a herring-bait near the Bass Rock, came into the possession of Mr Jameson, Fishmonger, Edinburgh, who very kindly presented it to me for the Anatomical Museum of the University, so that I have been enabled to examine not only its external form, but various points in its internal anatomy.

The figures of this shark, which have been published by Dr Andrew Smith, Yarrell, Hamilton and Couch, differ considerably from each other, not only in the general form of the fish, but in several points of detail. Dr Andrew Smith[1] figures under the name of *E. obesus* a male specimen of this shark, which is thicker, especially at the root of the tail, than my example, and his figure is copied by Yarrell (2nd ed. p. 534). Yarrell also figures another example, the sex of which is not stated (though from the appearance of claspers on the ventral fins it would seem also to be a male), which is much more slender than Dr Smith's specimen. Hamilton's figure[2] errs in making the snout too long, the gill-openings of equal size, and

[1] *Zoology of South Africa. Pisces*, Pl. I.
[2] 'Ichthyology' in *Naturalist's Library*, Vol. vi. Pl. 28.

in the relative size of the two dorsal fins. Couch[1] also errs in the relative size of the two dorsal fins, in the relative size and position of the gill-openings, and in the shape of the tail; moreover, the colour of the fish is much too pale. Neither he nor Hamilton state the sex of the specimens which they have figured. As no authentic figure of a female spiny shark has been published, I have thought it not undesirable to reproduce some careful drawings of my specimen, which were executed under my superintendence by Mr. C. Berjeau.

The measurements of this specimen were as follows:

	ft.	in.
Extreme length	6	6
Snout to eye	0	6
.... spiracle	0	10
.... nostril	0	3¾
.... mouth	0	6
.... 1st gill-opening	1	3
.... anterior root of pectoral fin	1	7
.... anterior border of 1st dorsal fin	3	8
.... anterior border of 2nd dorsal fin	4	4
.... anterior border of root of ventral fin	3	5½
Antero-posterior diameter of root of pectoral fin	0	6¼
Length of same fin	0	8
Antero-posterior diameter of root of ventral fin	0	9½
Length of anterior edge of ventral fin	0	8
Antero-posterior diameter of root of 1st dorsal	0	5
.... 2nd dorsal	0	4¼
Height of 1st dorsal	0	5
.... 2nd dorsal	0	3¾
Length of tail	1	10½
Greatest breadth of tail	0	8½
Girth of root of tail	0	11½
...... in front of ventral fin	1	11¼
.... pectoral fin	2	0
Transverse diameter of head between eyes	0	7
.... nostrils	0	3¾
Width of mouth	0	8

[1] *Fishes of the British Islands*, Vol. I. Pl. 12.

Head compressed from above downwards, almost flat on dorsum, with a rounded, shovel-shaped snout. Eyes on side of head. Spiracles above and behind the eyes, so small as to be capable only of just admitting a dissecting-room blowpipe; 5 gill-openings, the vertical slits at right angles to anterior border of pectoral fin, the 5th about twice the diameter of the 1st. Nostrils transverse, each partially divided by a narrow transverse membranous band, extending backwards from its anterior margin. Pectoral fin broadly quadrilateral, its posterior edge the shortest; ventral fin quadrilateral and elongated, its posterior border the shortest; 1st dorsal opposite the ventral; 2nd dorsal opposite the interval between the ventral and caudal fins. The girth behind the ventrals proportionally less than in Smith's and Couch's figures. Lateral line very distinct. Colour of back and sides darkish grey with an under tint of pink or even purple. Belly lighter in tint than back and sides; under surface of head yellowish brown. Fins closely similar in colour to the sides of the fish. The ventral and dorsal fins lie behind a vertical line drawn midway between the tip of snout and tip of tail.

The tegumentary plates with their recurved spines were irregularly scattered over the whole surface of the body, head and fins. At the anterior part of the snout and near the free borders of the fins they were much smaller than on the surface of the body. Not unfrequently 2, 3 or 4 plates were blended together; in one spot, indeed, I saw 8 and in another 13 spinous plates fused together. The skin immediately behind the posterior border of the ventral, pectoral and dorsal fins was free from spines, so as not to obstruct the free play of these organs. The tegumentary covers of the gill-clefts were almost entirely without spines, except that in front of the 1st cleft, which was thickly covered. Four rows of teeth were present in each of the jaws; one erect and in position on the margin of the jaw; three recumbent on its inner surface. The form of the teeth corresponded with Dr Andrew Smith's figure.

The ovaries, two in number, situated in the anterior part of the abdomen, between 8 and 9 inches long, were separated from each other by the meso-gastrium. Each became attenuated in front and behind, was laterally compressed, with longitudinal

Fig. 1. Profile view of female Echinorhinus spinosus, reduced $\frac{1}{11}$th. *sp.* spiracle, *n.* nostril.

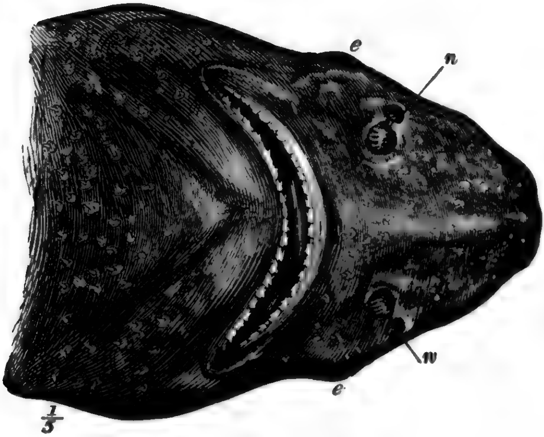


Fig. 2. Under surface of head reduced $\frac{1}{5}$th. *e*, *e* eyes, *n*, *n* nostrils.

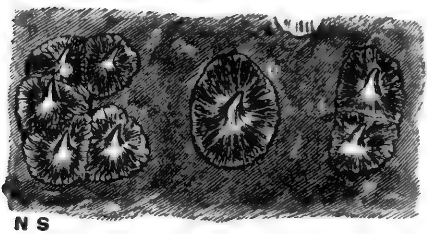


Fig. 3. Spiny scales, natural size.

folds and reddish in colour. Ova barely visible to naked eye. Oviducts about size of a crow-quill, each situated half-an-inch external to its ovary, but extending forwards beyond it; the left ended by a dilated mouth 3 inches in front of the left ovary, whilst the right extended 9 inches in front of the right ovary, reaching the pericardium and curving somewhat downwards. A moderator band, 5¼ inches long, passed between the anterior ends of the two oviducts. The oviducts extended backwards to the region of the cloaca, and in the hinder part of the abdomen, where the kidneys became prominent, lay on the ventral aspect of those organs.

The cloaca, 2 inches in its antero-posterior diameter, was elliptical in form and surrounded by a muco-tegumentary fold. The rectum opened by a wide orifice into its anterior part, and at the posterior border of the muco-tegumentary fold two abdominal pores, each so large as to admit a full-sized catheter, communicated with the peritoneal cavity. In the upper wall of the cloaca was a distinct papilla, at the summit of which an orifice just visible to the naked eye was seen. When the papilla was compressed a little brownish-yellow fluid oozed through the opening. A very fine injecting-pipe was then introduced into the orifice, and a blue injection passed into it, which distended the two ureters and entered the substance of the kidneys; the orifice was thus proved to be common to the two ureters. The kidneys did not extend so far forward in the abdominal cavity as is usual in fish. The anterior end of each gland was opposite the posterior end of the ovary and was broken up into scattered lobules, which only united together into a compact organ in the hinder third of the cavity. The ureter emerged from the gland about 6 inches in front of the cloaca and extended backwards in relation to the inner border of its kidney.

On each side of the cloacal papilla an elevated fold of the mucous membrane passed forwards and outwards in the upper wall of the cloaca to lose itself in a fossa in this wall. The lower margin of this fold was free and enclosed a minute tube, which was continuous with and formed the posterior end of the oviduct. This I proved by injecting it from the intra-abdominal part of the oviduct. This duct diminishes therefore so materially in size in the cloacal wall, as to be little more than capillary, and its orifice situated close to the common opening of the ureters was so minute that it required the use of a pocket-lens to see it. No appearance of a cement-gland was seen in the course of the oviduct.

From the absence of a cement-gland the ova cannot receive a horny case, and from the very minute size of the terminal part of the oviducts and genital pores, unless the oviducts become greatly dilated when the fish is sexually ripe, the ova cannot attain any very great size, and in all probability are impregnated after being extruded.

The heart, as in other sharks, consisted of an auricle, a ventricle, and a muscular conus arteriosus. The conus contained three tiers of valves, all the segments of which were small and semilunar. In each of the posterior and middle tiers the segments were two in number, but in the anterior three. Distinct intervals existed between the segments in each tier. Moreover three large semilunar valves were situated at the anterior end of the conus, where the aorta arose from it. The aorta gave origin to four pairs of branchial arterial arches, and each of the anterior terminal pair divided into two immediately after its origin, so that five pairs passed outwards to the branchiæ.

As the liver and alimentary canal had been removed by the fishermen before the shark came into my possession, I was much disappointed at not being able to examine the alimentary apparatus. Being in London however shortly afterwards, Prof. Flower told me that he had recently placed in the Hunterian Museum the alimentary canal of a female *Echinorhinus spinosus*, caught at Mevagissy, Cornwall, in May, 1872, and kindly gave me permission to examine and describe it[1].

The stomach formed a capacious sac, from the posterior end of which a pyloric tube proceeded, which ran forwards for 8 inches attached to the wall of the stomach by a peritoneal fold, and then curving backwards, ended in the straight intestine. The gastric end of the pyloric tube had a well-marked opening bounded by a semilunar fold of mucous membrane: its duodenal orifice was so constricted as only to admit a glass rod. The

[1] From a drawing of this specimen made by Prof. Flower, there can be no doubt that it closely corresponded in shape with the fish which I have figured.

straight intestine was 24 inches long, and ran almost directly backwards to the cloaca; its calibre was about three times as great as that of the pyloric tube, but the duodenal end was not so dilated as the part which contained the spiral valve. No "pyloric cœca" opened into the duodenum. The fold of mucous membrane, which marked the commencement of the spiral valve, began about 1 inch from the pyloric tube, and passed at first almost longitudinally backwards; it then became more oblique in its direction, and as it approached the rectum was almost transverse. The anterior end of the straight intestine is to be regarded as the duodenum, for the bile-duct opened into it by a distinct orifice about 3 inches behind the pyloric tube. The pancreatic duct had not been bristled, and its opening could not be seen in the mounted preparation. The mucous lining of the duodenum and of the spiral part of the gut was flocculent and villous. The rectum was short and had the usual botryoidal gland opening into it, its mucous membrane was smooth. The liver was bilobed, with a pyriform gall-bladder. About 2 inches before the gall-duct reached the duodenum, a small appendage, similar in appearance to what I have described in the Greenland shark, was seen in relation to it. The reniform spleen, about the size of the human spleen and smooth on its surface, was attached by peritoneum to the posterior end of the stomach. A second organ, about 4 inches long, flattened and almost smooth on the surface, which Prof. Flower regards as a supplementary spleen, was situated anterior and close to the duodenum. A third organ, about 2 inches long, probably a pancreas, lay in the concavity of the curve formed by the duodenum and pyloric tube.

As Müller and Henle in their great work on the classification of the Plagiostomata (p. 96) had placed the genus *Echinorhinus* in close relation to *Læmargus*, owing to a certain amount of correspondence in external characters, and as Duméril (p. 458) and Günther (VIII. p. 356) have adopted a similar arrangement, I examined the alimentary and genital apparatus of the spiny shark with great interest in order to see if these organs corresponded with the arrangement I have described in the Greenland shark[1]. A comparison of the descriptions which

[1] *Journal of Anatomy and Physiology*, Vol. VII. p. 233, and Vol. VIII. p.285.

I have given, will at once shew that these sharks differed very materially from each other, for whilst in the Greenland shark two large duodenal cœca existed along with a well-developed pancreas, in the spiny shark no duodenal cœca were present: and whilst no oviducts were recognised in *Læmargus*, a pair of distinct ducts opening at the cloaca were found in *Echinorhinus*. It seems to me therefore that these internal differences in anatomical structure so far outweigh in their morphological importance the resemblances in external characters, that *Læmargus* and *Echinorhinus* should no longer be included in the same family.

ON THE PRESENCE OF SPIRACLES IN THE PORBEAGLE SHARK (*LAMNA CORNUBICA*). By Professor TURNER.

ZOOLOGICAL writers differ in their statements as to the spiracles in the Porbeagle. Hamilton in the volume on Fishes in the Naturalist's Library, and Thompson in the Natural History of Ireland, do not refer to them. Fleming in his account of British Animals, Parnell in his description of the fishes of the Firth of Forth, and Couch in his Fishes of the British Islands, state that they are wanting. On the other hand, Müller and Henle say in their great work on the Plagiostomata that they are present, very small and some distance behind the eyes: they give the credit of the discovery to Dr Andrew Smith. In the 2nd edition of Yarrell's British Fishes they are also said to be present and very small. Duméril in his *Histoire Naturelle des Poissons* gives a minute description of their position, but states that they are so small as easily to be overlooked. Lastly, Dr Günther in the 8th vol. of the Catalogue of British Fishes, p. 389, 1870, says that they are absent in the Porbeagle, though a minute pore-like foramen was present on one side of an example of *Lamna spallanzani*.

In December, 1874, I purchased from one of the Edinburgh fishmongers a young female Porbeagle, captured off the mouth of the Firth of Forth, which measured 3 ft. 5½ in. from the tip of the snout to the tip of the tail. It was perfectly fresh, so that I was able satisfactorily to enquire into the much-disputed question of the presence or absence of a pair of spiracles. On carefully examining the top and side of the head I found a minute orifice 1⅝ in. behind the posterior border of each eye-aperture, 5½ in. behind the tip of the snout, and just above a horizontal line prolonged backwards through the centre of the eye-aperture. A vertical line drawn from this orifice down the side of the head passed immediately behind the angle of the mouth. The orifice just admitted a pig's bristle, which could be passed through it into a canal that ran almost vertically downwards, to open by a wider orifice into a fossa, communicating with the cavity of the mouth, situated immediately within the dental border of the jaw, about 1½ in. in front of the hinder end of the dental arch.

The opening of this canal on the surface of the integument was coloured with a darker pigment than the surrounding skin; and as its lining membrane was moister than the integument, the light was so reflected from it as to attract my attention to the aperture. There could be no doubt therefore that the pair of symmetrically-placed openings and their canals were the spiracles, so that these passages, though very minute, were yet present in this specimen of the Porbeagle.

NOTES ON THE GREAT SPLANCHNIC GANGLION.

By D. J. Cunningham, M.B., C.M., *Demonstrator of Anatomy, Edinburgh University.*

By those authors who take notice of this ganglion it is described as of rare occurrence, and few enter into any particulars as to its Anatomy. Henle it is true mentions it (*Handbuch der Systematischen Anatomie*, Band III. p. 579), but his account is brief, and he quotes Lobstein and Rüdinger as his authorities. The former, in his work upon the Sympathetic System describes it on the strength of two cases. Rüdinger, however, was more familiar with the ganglion, and in one case in which it was present on both sides of the body, he states that he was able to trace fine twigs of communication passing from one to the other behind the aorta.

Having met with a beautiful example of this ganglion at the beginning of last session, whilst dissecting out the splanchnic nerves in the Practical Anatomy Rooms of the Edinburgh University, my curiosity was raised, and I proceeded to investigate the subject with the view of finding out first the frequency with which it occurred, and second its connections with, and relations to neighbouring parts. I have made in all 26 dissections of the great splanchnic nerve, and I now propose to make known the results.

Frequency of occurrence. In six of these 26 dissections I failed to discover the ganglion. In three of the cases in which it was absent, however, the nerve-trunk was slightly swollen at the point where the ganglion is usually situated, and gave off fine twigs to the aortic coats, and in one case a long branch which passed down upon the aorta under cover of the crus of the diaphragm. Although I did not in those cases examine the nerve microscopically, yet it is not improbable, from the fine twigs which arose from the nerve in this place, that a minute ganglion—too small to be seen by the naked eye—may have existed. Eleven of the dissections were made upon the right side of the body, and in all those the ganglion was present. Of the fifteen dissections made upon the left side the ganglion was absent in six cases. As far as I could judge it occurred as frequently in the one sex as in the other. On one occasion two ganglia were present upon the same nerve-trunk—one occupying the usual position and the other situated upon the body of the 10th dorsal vertebra at the point where the root from the 8th dorsal sympathetic ganglion joined the great splanchnic. This additional ganglion was small in size, oval in shape, and gave off several twigs to the aortic plexus.

Position and relation to the Splanchnic Trunk. In the majority of cases the ganglion is developed upon that part of the splanchnic nerve which is joined by the last root from the sympathetic cord, and its position is very constant, viz. upon the body of the 12th dorsal vertebra, or upon the intervertebral disc, which intervenes between the 11th and 12th dorsal vertebræ. In one case it was situated upon the body of the 10th dorsal vertebra; but here the splanchnic nerve showed even a greater deviation from its *typical* descriptive origin than it usually does. It arose by three roots, one a very fine twig from the 5th dorsal ganglion, another from the 11th, and the third (a large branch which made up the chief bulk of the nerve) from the 8th, and it was upon this root that the ganglion was developed. The relation which the great splanchnic ganglion bears to the great splanchnic nerve is very variable. Sometimes the whole of the splanchnic fibres appear to pass through it; this, however, is rare. Perhaps the most common form is where the nerve divides into two branches upon the anterior of which the ganglion is developed, whilst below this point the two branches unite. Again, we may simply notice a marked bulging of the splanchnic. This indicates the presence of a small mass of grey matter surrounded on all sides by the fibres of the nerve, and which can be easily enucleated by separation of these fibres the one from the other. Occasionally the ganglion is placed in the interval between the aorta and the nerve, and only connected with the latter by numerous short communicating branches. In this case it is generally very minute, and unless great care be taken in the dissection, it is sure to be overlooked.

Shape and size. In both these respects the ganglion is very variable. In shape, it may be semilunar, oval, fusiform, or even linear. Occasionally, it is triangular, and connected by its base with the anterior surface of the great splanchnic nerve. Its size varies from that of an orange-seed to that of a pin's head. In one case, where the sympathetic system was hypertrophied, it was almost as large as an almond. In all cases its ganglionic character may be satisfactorily determined by the microscope. Its cells are numerous, large, and ovoid in shape.

Branches. The chief object of this ganglion seems to be to furnish numerous delicate twigs to a nerve-plexus situated on the lower end of the thoracic and the commencement of the abdominal aorta. These are generally from 5 to 9 in number, and after joining each other in a plexiform manner, they are lost upon the coats of the aorta. In some cases branches may be traced to the cœliac and superior mesenteric plexuses; and once I even succeeded in following a very fine twig into the renal plexus, to reach which it passed down upon the bodies of the vertebræ under cover of the crus of the diaphragm. Lobstein states that certain branches may be found which end in the muscular substance of the crus. I consider this very doubtful, as I have never seen any branch from the great splanchnic ganglion enter the crus to end there. Again, I have never been able to trace filaments connecting *directly* the ganglion of the one side with that of the other. Rüdinger maintains that such exist, but I am of opinion that the two ganglia are in relation the one to the other simply through the medium of the intervening aortic plexus. We sometimes find that the great splanchnic entering the ganglion as a single trunk emerges as two, both of which as a rule pierce the crus to end in the semilunar ganglion. The posterior and smaller of these branches however may join the small splanchnic nerve close to its termination. This communication, whether it takes place in the manner I have mentioned, or by an independent branch from the ganglion, is by no means uncommon.

LATERAL CURVATURE OF THE SPINE IN CONJUNCTION WITH HYPERTROPHY OF THE SYMPATHETIC NERVOUS SYSTEM IN THE LUMBAR AND SACRAL REGIONS. By D. J. Cunningham, M.B., C.M. *Demonstrator of Anatomy, Edinburgh University.*

A case of this occurred last session in the Practical Anatomy Rooms of the Edinburgh University, and I am induced to publish it as it presents a double interest—first, on account of the peculiar nature of the curvature; and second, on account of the curious relationship which existed between this and the hypertrophied sympathetic system.

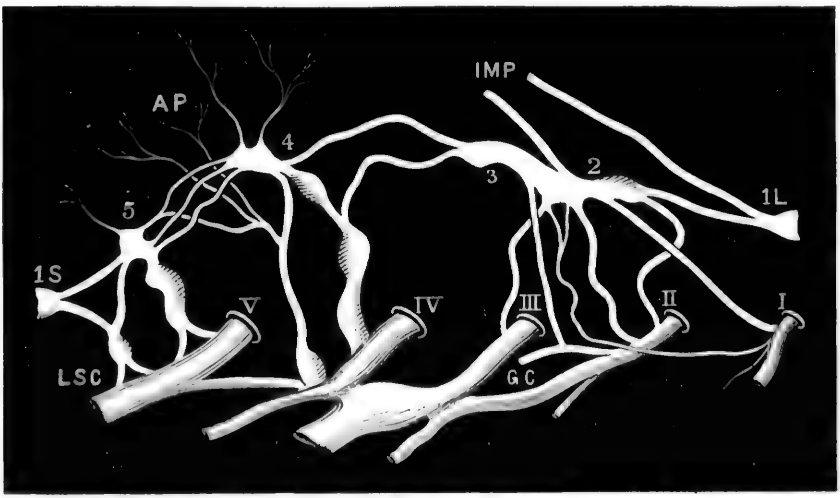
The subject in which it occurred was a man of, I should say, between 40 and 50 years of age, and his spine showed a well-marked lateral curve in the lower dorsal and lumbar regions. This deviation commenced very abruptly at the level of the 11th dorsal vertebra, included it, and extended down to the level of the 5th lumbar vertebra—the convexity of the curve being directed to the left side and the concavity to the right. A cord placed on the right side of the spine and held with its two ends in contact with the piers of the arch was distant about 1½ inches from the point of greatest concavity. A well-marked counteracting curvature was present in the sacral region—the left margin of this bone being considerably shorter than the right; and the point of greatest convexity in this arch was represented by the right superior corner of the sacrum. Moreover, there was a slight falling back of the lumbar vertebræ—the forward curve in this region being less marked than it usually is. The uniformity of the curvature was everywhere interrupted by nodular projections varying in size from that of a hazel-nut to that of a hen's egg; and it might be seen that these nodules sprang chiefly from that part of the spinal pillar which corresponded with the intervertebral discs. On examining the spine from behind, the spinous processes in the region of the curvature did not exhibit so marked a deviation from the middle line as the bodies;

this was due to the twisting of the vertebræ around their long axis towards the left side.

The periosteum investing the vertebræ, implicated in this curvature, was almost cartilaginous in consistence, and very much thickened. In some parts it presented a thickness of more than a quarter of an inch. On stripping it off, the bodies of the vertebræ were found to be considerably larger than normal—their texture being much opened up and everywhere presenting the enlarged orifices of the Haversian canals, into which passed vessels of corresponding size. The majority of these vessels had been filled during the injection of the arteries with the ordinary coarse injection of lard and vermilion, and some indeed presented a calibre almost equal to that of the spermatic artery. The bodies of the vertebræ were firmly anchylosed, the one to the other, so as to form a solid osseous pillar from the 11th dorsal to the 5th lumbar vertebra; and the nodular outgrowths of new bone were in some cases so soft as to crumble under the finger, but in others they were covered by a thick and dense shell of osseous tissue. Posteriorly the lumbar articular processes and laminæ were also welded together by osseous union, and projecting from the posterior aspect of the solid bony arch thus formed were numerous large nodules of new bone, similar in all respects to those present on the anterior segment of the spine. The transverse processes in this region were much distorted, enlarged and opened out in texture, and of the spinous processes several were united by anchylosis along their whole length so as to form a continuous osseous plate projecting back from the laminæ.

From this description it will at once be seen that the curvature could not be due to caries, for in that case we should expect to find a greater degree of angular deformity and a loss, not an increase, of the substance of the vertebral bodies. It is curious, however, to find true anchylosis of the posterior segment of the spine so well marked—this generally being a prominent feature in advanced caries of the bodies, in which disease it constitutes a reparative process. That the condition was the result of inflammatory action of some kind affecting both the bodies and neural arches of the vertebræ, is very evident from the proofs which were everywhere present of excited action, viz. the thickened periosteum, the opening up of the osseous texture, and its great increase in quantity. The first stage must doubtless have been one of softening and stretching of ligaments; this must have been followed by bulging of the spine to the left side, and then the inflammation seems to have abated and a healthy reaction to have ensued, whereby the vertebræ were welded together by new bone. In caries we have a destructive process taking place in the anterior segment of the spine, whilst a formative process is going on in the posterior segment; in this case the formative process has predominated in both segments.

Perhaps the most interesting feature of this case, however, was the peculiar hypertrophy presented by the sympathetic system in the regions corresponding to the curvature. The accompanying diagram shows this enlargement as it existed in the lumbar region—the nerves having been reduced one-half.



Explanation of Figure.

I to V, lumbar spinal nerves. L 1, 2, 3, 4, 5, lumbar ganglia of sympathetic, 1S, 1st sacral ganglion, LSC, lumbo-sacral cord. GC, genito-crural nerve, IMP, branches to inferior mesenteric plexus. AP branch to aortic plexus.

This condition of the nerves was almost exclusively confined to the left side of the body, or that towards which the convexity of the curvature was directed. On the right side only one ganglion was abnormally increased in size, and this was situated on the summit of a large osseous nodule projecting from the concavity. On the left side the hypertrophy extended from the 11th dorsal ganglion to the 3rd sacral ganglion, and was tolerably uniform in its character. In some parts the sympathetic cord was completely embedded in the thickened periosteum, and in cutting into this the cord was seen to occupy a distinct tubular canal, the walls of which were in no way connected with the sheath of the nerve. The enlargement was more evident in the branches of the ganglia than in the ganglia themselves. The ganglia which presented the greatest increase in size were the 11th and 12th dorsal, which were fused together into a body about 2 inches long by ½ an inch broad, and the 2nd and 3rd sacral, which were also amalgamated, constituting an elongated, thickened, and rounded body 1½ inches long and 1¼ inches in girth. The great splanchnic ganglion was one inch in length and ¾ of an inch in girth at its thickest part; and proceeding from it were numerous branches, of which two entered the semilunar ganglion and were as large as the normal pneumogastric. As a rule, the nerves issuing from the ganglia were uniformly enlarged; some, however, presented a slightly moniliform appearance from the occurrence of oval swellings upon their trunks. The branches of communication to the lumbar spinal nerves were relatively more enlarged than the branches which passed forward towards the aorta. Of the former some were as large, if not larger, than the median nerve of the upper extremity, but the majority presented a thickness corresponding to that of the pneumogastric. Numerous fine sympathetic twigs could be traced to the vertebral bodies, into the interior of which they passed in company with the enlarged Haversian vessels; and thus by means of this specimen a ready demonstration was afforded of the entrance of nerves into bones, which is so difficult to prove in cases where the nerves are of normal size.

This nerve-hypertrophy was undoubtedly due to great increase of the connective-tissue-elements of the nerves. It was, in fact, simply a great fibrous development of the sympathetic system. Mr A. B. Stirling kindly made several microscopic preparations of the 2nd and 3rd sacral ganglia. In these the neurilemma of the nerve-fibres is seen to be very much thickened, and the nerve-cells are observed to be few in number, much altered in appearance, and in many cases affected with fatty degeneration.

At first I was inclined to believe that this case was fibro-neuromatous in its character, and analogous to the case recorded by Berard in 1827, and quoted by Cruveilhier in his work upon *Pathological Anatomy*. In Berard's case it was the cervical sympathetic which was enlarged, and the enlargement showed itself in the shape of a number of tumours situated on the left side of the spine and freely communicating the one with the other, and also with the cervical spinal nerves. The uniformity of the hypertrophy, however, forced me to abandon this view, and I am now of opinion that the true cause is to be found in the extension of the inflammation from the periosteum to the nervous tissue. Why the condition should only have occurred on the left side is more difficult to explain, but I think that it was due to the stretching of the sympathetic over the convexity of the curvature, and to the closer apposition, which must have existed, between the inflamed tissue and the nerves on the left side than upon the right. And this view is supported by the fact, that the only point where hypertrophy was present on the right side was where the sympathetic passed over a large nodule of new bone.

I regret very much that I can give no history of this case. This I regret all the more, as several cases of idiocy and cretinism are recorded as being associated with fibro-development of the ganglionic system.

In conclusion, I have to thank Mr A. H. Young, Assistant-Demonstrator of Anatomy, for the great care he bestowed upon the accompanying diagram, and also Mr Kirk, student of medicine, for his kind assistance in the dissection of the sympathetic system. The spine which I have described is now in the Anatomical Museum of this University, and I have in my possession careful drawings (executed by Mr Young) of the sympathetic system from the 11th dorsal ganglion downwards.

REMARKS ON THE POSITION OF THE FEMUR AND ON ITS SO-CALLED "TRUE NECK." By THOMAS DWIGHT, F.M.D., Boston, U. S. A., *Professor of Anatomy at the Medical School of Maine.*

AMONG the most interesting points in the recent discussions on the structure of the neck of the femur, is the signification of the plate named by Prof. Merkel[1] of Rostock, the Schenkelsporn or Calcar Femorale, and by Prof. Bigelow[2], of Boston, the True Neck of the femur. The study of a large number of human and of several other mammalian thigh-bones has led me to conclusions other than those of either of these observers, as well as to different views on the statics of the bone. I have little to add to previous descriptions. The plate in question is the result of a splitting of the posterior wall of the neck into two layers, one of which continues to form the surface of the bone, while the other runs downwards to the lower wall of the neck, and outwards toward the external surface below the great trochanter. It varies greatly in degree of development; if strongly marked, it runs for some distance as a distinct plate, and then subdivides into several, some of which are continuous with the cancellated tissue that surrounds the upper part of the cavity of the shaft; if weak, it breaks up at once into diverging laminæ, which pursue the same general direction but have no very definite terminations. The best section to show this structure is one parallel with the lower surface of the neck.

Professor Merkel shows that this plate is situated in the part of the neck through which the chief part of the weight of the body is transmitted to the leg, and holds that its signification is purely teleological. He states that sections through the bones of animals show that it is present in such as need it, and not in others. Prof. Bigelow considers it of little value except in cases of uncommon development. From the appear-

1 *Virchow's Archiv*, 1874.

2 *The Hip* (Philadelphia, Henry C. Lea) 1869, p. 120; also the *Boston Medical and Surgical Journal*, 1875, Nos. 1 and 2.

ance such specimens present, he looks upon it as the true neck to which the trochanters and the posterior intertrochanteric ridge have been added for muscular attachments. He intimates that the posterior wall of the neck of the femur of the sheep would be analogous to this plate were a certain amount of spongy tissue added to the hinder surface of the former.

If this view holds, we should expect, wherever a process exists solely for muscular attachment and is out of the line of support, to find under its cancellated tissue a continuation of the compact substance of the shaft. Such an arrangement is, indeed, found in some places. It occurs under the anterior intertrochanteric ridge, and sometimes under the coronoid process of the ulna and the tubercle of the radius. On the other hand, it does not occur under several other prominences on the human skeleton where it might with equal justice be expected. Nowhere should we look for it with greater confidence than under the third trochanter of the horse, but, as a cross section shows, there is no trace of a partition between the spongy tissue of the shaft and that of the process. Thus it appears that there are serious objections to the name the "true neck", though it may be proper to retain it as it is the original one, especially as "femoral spur" is quite inappropriate.

If Merkel's premises as to the position of the femur are to be accepted as bearing upon the question, his conclusions may also be agreed to with the modification that, as Bigelow declares is the case, the plate can be of no great value unless exceptionally developed. The question, however, arises, whether what is called the usual position of the femur, namely, that which it has when the knees and heels are together, can be made the basis of correct calculations. This position is constrained and unnatural, and is never voluntarily maintained for more than a few moments, nevertheless it has apparently been assumed to be the normal one by most observers, and it seems as if some had made the greater mistake of assuming the shaft to be vertical. This error invalidates Prof. Culmann's elaborate calculations[1], for the shaft of his crane, the lines of which are supposed to correspond to the plates in the neck of the femur, is drawn vertically. No mathematical proficiency is needed to

[1] Wolff, *Virchow's Archiv*, 1870.

know that what is true of an upright rod is not necessarily so of an inclined one. It is essential, in considering the structure of the femur in relation to the weight it sustains, to put the bone, as nearly as possible, in the position it occupies when in use as a support. This position is not a constant one, and cannot be accurately defined; but it is one of greater inclination than is possible when the knees are in contact. When on our feet we are almost always, if the expression may be pardoned, more or less in motion. That is, we are rarely in absolute rest, but, if not walking, regularly are, at least, slightly changing position. In the walk, as is well known, the pelvis at every step sways to the side of the supporting foot, thus increasing the obliquity of the femur. When standing still, the weight is very seldom equally divided between the legs, but one bears almost the whole of it, while the other does little more than maintain the balance. It would be absurd to attempt to define the average inclination of the femur, varying as it must with the length of the legs and the breadth of the pelvis, but it must be appreciably greater than it is in the conventional position. Now this is of advantage, not only by making the neck more nearly vertical, but also by bringing the "true neck" into play. If strongly developed so as to reach the outer side of the shaft, it will evidently be of very great assistance, but even if slightly marked it will be valuable as a brace between the posterior and inferior surfaces of the neck.

A vertical section through both condyles and the lower part of the shaft shows an arrangement of the cancellated tissue calculated to strengthen, though but slightly, the bone in the inclined position. If the shaft be held upright, a series of layers is seen to be given off from each side of it and to run directly downwards; but there is also a series of delicate plates coming from the inner wall and running obliquely to about the middle of the lower end. If both condyles be made to rest on a table the plates of this set are nearly vertical, and if the bone be more inclined they are the ones in the least disadvantageous position. It is worthy of notice that this oblique series is not found in the posterior half of the lower end which has less to do with supporting the weight.

My observations in comparative anatomy (made mostly on bones belonging to the Boston Society of Natural History) are too few to be of much value, but, as far as they go, they are opposed to Merkel's statement that the "true neck" is of purely teleological signification. A section made through the neck of the femur of an adult female gorilla shows no distinct plate, but a number of laminæ are successively given off from the outer half of the posterior surface of the neck and run outward, presenting a decided contrast to the irregular network anterior to them. In the mandrill the plate is fairly developed, perhaps as well as in the average human femur. It is absent in the tiger, the horse, and the beaver; very indistinct in the bear, but quite clear in the goat and the kangaroo. It is hardly possibly to trace in this series any relation between structure and function, but it does not follow from this that the plate in question is useless in man. The round ligament of the hip is an instance of a structure of undoubted value to man, but which is found variously developed and may be wanting, while among animals it is absent in some nearly allied to others possessing it.

THE CHARACTERISTIC SIGN OF CARDIAC MUSCULAR MOVEMENT. By Dr Hugo Kronecker, from Experiments done in conjunction with Wm. Stirling, D. Sc., M.B.C.M., *Demonstrator of Practical Physiology in the University of Edinburgh*[1].

"The induction-current of weakest strength which produces a contraction of the heart, does not produce the weakest of possible contractions, and the extent of the latter also does not exceed an impassable maximum, when the intensity of the exciting current is increased. On our object (the ventricle of the frog's heart) the induction-current either produces a contraction, or it does not; and when it does the former, it causes at the same time the most extensive contraction which the induction-current at a given time can produce. It therefore follows directly that the cause why the apex of the heart contracts to different extents is to be sought in the variable properties of its muscular fibres."

This fundamental law of the movement of the cardiac muscles is one of the most important results of the investigations of Bowditch, "Ueber die Eigenthümlichkeiten der Reizbarkeit, welche die Muskelfasern des Herzens zeigen." (*Arbeiten aus d. physiologischen Anstalt zu Leipzig*, Jahrgang, 1871, p. 174.)

Now in the course of these important experiments several remarkable phenomena, constantly recurring under quite distinct conditions, appeared, to whose interpretation it appears necessary to limit the fundamental law.

But just as the disturbances in the course of the planets, instead of threatening the universality of Newton's law of gravitation, as often as their cause was discovered, confirmed this most beautifully, so have—*si parva licet componere magnis*—the peculiarities which appeared to disturb the simple view of the irritability of the heart, by continued testing, with the

[1] This paper was originally published in German as one of the *Beitraege zur Anatomie u. Physiologie, als Festgabe Carl Ludwig zum* 15 *October*, 1874, *gewidmet von seinen Schülern*, Leipzig, 1875.

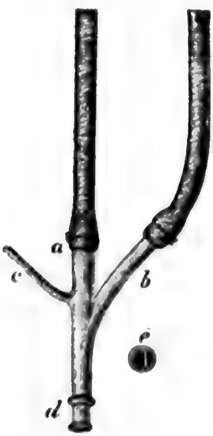
help of the improved experimental methods of Bowditch and Luciani, proved themselves as completely supporting the fundamental law cited at the beginning.

The essential task of the following paper shall be to give this proof.

As experimental aid we employed the frog's heart manometer, at first with the modifications which are given in Luciani's paper, "Eine periodische Function des isolirten Froschherzens" (*Arbeiten aus d phys. Anstalt zu Leipzig*, 1872), later, connected with a system of tubes employed by Bowditch, which permitted, by means of three glass stop-cocks with T-formed perforations, the placing of the ventricle at one time in connection with the reservoir feeding the same, at another in connection with the manometer, whilst at another it could be brought in connection with the outflow tube by which the heart could empty its contents externally.

We have employed a small new arrangement in order to be able to wash out the ventricle conveniently and very completely with the desired fluid. The German-silver "double-channelled cannula" for the frog's heart is here figured of the natural size (Fig. 1). The slightly thickened end *d* is insinuated through the incised sinus venosus of a large frog's heart into the ventricle, after this has been previously carefully cleared of blood coagula by twisted filtering paper. The ring placed on the chief tube 4 mm. above the opening, serves as a point for fixing the ligature, with which at first the auricles near to the sinus venosus are firmly tied round the tube. Now one can, without the cannula being liable to slip out of the ventricle, place a ligature below the atrio-ventricular sulcus around the ventricular muscular fibres, and therewith, according as one desires, suppress the automatic cardiac movements. The cannula divides into two tubes *a* and *b*. A partition which passes from the point of bifurcation to the chief orifice divides the chief tube into two unequal sections; in this way, that the

Fig. 1.



transverse section *e* is divided into two segments, of which the one occupies one-third the other two-thirds of the contents of the circle. Thus the cylinder is divided into two separate longitudinal sections, of which the larger communicates with the forked tube *a*, whilst the smaller one communicates with the tube *b*.

The caoutchouc tube on *b*, according to the position of the glass stop-cock in the system of tubes, serves to conduct the nutrient fluid from the reservoir through the narrow section of the tube into the heart, or allow the contents of the ventricle to flow out.

The wider section of the tube *a* is intended to establish a communication between the interior of the heart and the mercury-manometer. The float of the mercury-manometer, bent from a fine glass thread, weighted with a luted small glass ball, marks exactly the form and size of the heart-beats upon the smoked glazed-paper covering of a very regularly rotating kymograph cylinder. The German-silver wire soldered to the cannula, conducts on the one hand the rhythmically produced induction-currents from a large induction-apparatus to the heart, whilst a gold-plated brass vessel filled with the nutrient fluid in which the heart is bathed, is connected with the other pole of the secondary spiral.

We regarded it as our first task to respond to the wish indicated in the paper of Bowditch, where the dependence of the work of the heart on the strength of the stimulus is discussed (*loc. cit.* p. 175). It was shown that minimal stimuli, *i. e.* those which are just capable of producing a cardiac contraction, do not do this every time, and that, in spite of a regular rhythmical succession of stimuli, the pulsations are discontinued in an irregular manner. "The falling out of the contractions may be explained in two ways; either that the susceptibility of the muscular fibres for the stimulus becomes smaller...or that the *stimulus itself loses its strength.* In that, during poisoning with muscarin, the induction-current, in order to remain infallible as a stimulus, need not be strengthened, so it inclines one to the view, as if thereby it was decided in favour of the second of the mentioned possibilities......It is to be remembered that in my experiments the gradation of the stimuli was not nearly so nicely carried out as it was capable of." By this view we were encouraged to undertake a new testing of the irritability of the ventricle, and at the same time admonished to pay special attention to the equality of the stimuli.

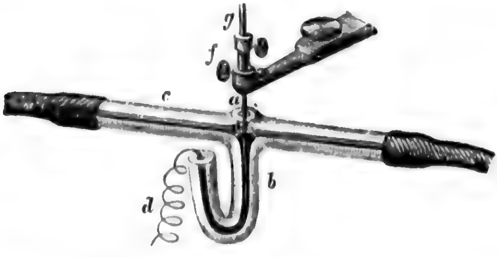
We soon remarked that the mercury contact of the relais which served for closing and opening the primary current was very difficult to keep clean.

The layer of oxide formed from the opening spark disturbed the conduction seriously, even after a few interruptions. The opening spark could not be sufficiently removed by introducing secondary closures. We tried to keep the surface of the mercury clean by means of a 'washing apparatus,' described by W. Stirling in another place (*Arbeiten aus d. phys. Anstalt zu Leipzig,* 1874). This succeeded tolerably well. But we reached our object more completely by means of an arrangement employed by Dr E. Tiegel. The mercury into which the platinum stilette of the relais ought to dip to close the primary circuit was placed in a capillary glass tube, above whose mouth it projected with a strong convex head. The mercury tube was sunk in a glass filled with alcohol. When the platinum stilette fell into the projecting head of mercury the layer of oxide of mercury was ruptured, and the effete particles flowed down from the slope of the mercury.

A more handy form of the "capillary-contact" is shown in Figure 2, of natural size.

A glass T-tube with a lumen of about 1·5 mm. is provided at the crossing point with a moderately wide opening *a*. The

Fig. 2.



vertical tube *b* is bent in the form of a U, and filled so full with mercury that the head of the mercury projects within the lumen of the transverse tube *c*. The one end is united by means of caoutchouc to a Mariotte's flask, which contains diluted alcohol, whose pressure-niveau remains at the same height as the hole *a*. A stop-cock regulates the supply to the transverse tube, from whose other end a longer narrower tube conducts away the washing fluid.

This suction-tube accelerates the current and draws through the opening *a* bubbles of air, which produce eddies, and thus help to cleanse the surface of mercury. The platinum stilette *e* at the end of the relais is united by the collar *f* with the transverse bar of the relais (and hereby with the positive pole of the battery). Still it is easily attracted. Such an arrangement permits of the removal, without any loss of time, of any film of oxide which may be adherent to the point of contact.

The platinum-wire *d* formed the circuit to the negative pole of the battery through the primary spiral of a du Bois-Reymond's induction-apparatus (secondary spiral 10,000 turns) graduated into current-unit (from 1 to 900). (Compare *Untersuchungen aus dem phys. Laboratorium d. Züricher Hochschule*, A. Fick, Wien, 1869, p. 38). If successful by means of the above-described arrangement in obtaining a sure closure of the primary circuit, we were unable to observe any interrupted ("aussetzenden") beats. *Every stimulation was either followed by a beat, or the stimuli remained quite without effect. Minimal* stimuli were at the same time *maximal*. When weakened only a little they remained ineffective. The ineffective stimuli appear to be without influence on the heart. It was therefore not necessary, when employing moderate opening induction-currents, that the closing shocks should be blended.

That adequate (hinreichende) stimuli in the series often become infallible seems to speak against the assumption that the cause of the inconstancy in the action of the stimulus does not lie in the animal tissues, but in the apparatus (Bowditch, *loc. cit.* p. 152), whilst still it may be assumed that the contact becomes always more imperfect by the continually increased products of decomposition. It is easy to prove however that the irritability of the heart is considerably increased by its movement, so that previously *ineffective* stimuli suffice to sustain the pulsations of the, as it were, wakened heart.

(A similar result was observed by Hoffa and Ludwig, "Versuche über Herzbewegung." *Zeitsch. f. rat. Medic.* 1850, p. 135.)

A pulse-beat renders more easy for some time the occurrence of the next one; rest of the heart renders its excitation more difficult. Sometimes the differences of the irritability before and after a few beats are very considerable, as in the experiment from which the following piece is taken (Fig. 3).

Here 200 current-units (E) were at first necessary to produce beats, then these did not fall out when the stimulus sank to $23E$, and ceased first at $22E$; were later first produced by a strength of current of $60E$, and continued even with $20E$. For the first pulse after a short pause $125E$ were necessary, for the second only 30 units.

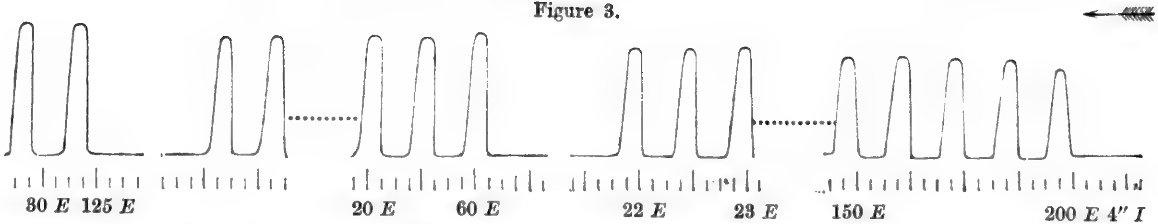
In by far the most cases however, the differences between the intensity of the stimuli sufficient for the excited heart, and of those acting upon the heart at rest, were very small; have often been only a fraction of a unit, as in Fig. 4.

Here the limits varied between 46,2 and $46{,}3E$; later 45,4 and $45{,}5E$. The heart therefore had increased in irritability, although the capability of energising (height of the beats) had fallen considerably. This can often be observed. These examples show, that the beats without passing through irregular ones, disappear at once completely, when the stimulus falls only a minimum below the infallible. The following continuous piece of curve may serve as an example of this (Fig. 6).

It can easily be shown that it is not a peculiar effect of the electric current which exalts the irritability of the ventricle, whereby previously inadequate stimuli become infallible, but that every impulse which produces a cardiac contraction can do this. Even heart-beats, produced by mechanical impulses, can restore to minimal electrical stimuli their already lost effect. In near relation to this is the observation of Luciani, that weak electrical stimuli, which were ineffective during the pause of a periodically spontaneous beating heart, were ineffective, but after the appearance of the first spontaneous beats of the next group, were effective. (*Arbeiten aus der phys. Anstalt zu Leipzig*, 1872, p. 183.)

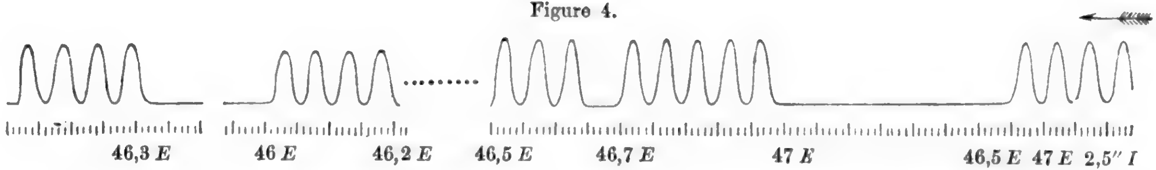
From the fact that a beat of the heart renders the next one more easy of accomplishment, the conception lies near at hand,

Figure 3.



Ventricle of a frog's heart filled with rabbit's serum, stimulated at intervals of 4″ with opening induction-shocks, whose intensity could be varied in a definite manner by pushing the secondary spiral upon the grooved path graduated into units *E*. The points indicate a series of similar beats not reproduced; the interruption of the abscissa line, long rest.

Figure 4.



Stimulation of the ventricle of a frog's heart in intervals of 2·5″ with opening induction-shocks, whose intensity was varied within narrow limits. The lines mark half seconds.

that the excitement lasts for a time, and during this time can be brought over the threshold ("über die Schwelle") by gentle impulses.

The following picture may serve to show what is meant. Just as a bell can be at once caused to resound by exercising great force, but if moved by moderate traction of the bell-ringer, it only gradually becomes more easy, till at last the clapper beats against the side. The first single tone resounds, and perhaps still one more, and now the full tone is sounded in measured rhythm. Not at once, however, when the ringing has ceased does the heavy mass come to rest. Once, or it may be several times, the clapper reaches the wall, and weak, well-timed impulses may cause the sound to be continued. If the vibration be not sufficient however, or becomes inactive, then sounds are only again produced by powerful pulling.

So the isolated frog's ventricle can always be caused to beat by strong stimuli. Only just adequate impulses, frequently after a prior beat (sometimes after a repeated one), cause an isorhythmical succession of beats, as is to be seen in Figs. 6 and 7. After the movement has once been set agoing, currents previously of insufficient intensity are capable of sustaining the pulsations. If however the impulse is too weak for this, the molecular movement can no longer be perceived, either at once or after a few beats. Up to this point the comparison holds good. The heart, however, is a living tissue of changeable properties. Small causes often produce important changes in structure.

The mobility of the muscular plasma and of the spinal cord are essentially influenced by the temperature of the organ, condition of the surrounding fluid, and in consequence also by the tissue changing and heating activity itself. As the effect of this last factor, we have already observed that the frog's ventricle in the course of its work became more easily excitable. Gradually the ventricle again loses its greater mobility, and reacts towards the end of its life only on employing strong stimuli. Also with the temperature the irritability of the heart increases within moderate limits. One can therefore make an inadequate stimulus effective by warming the heart. The processes then occur exactly as upon increasing the stimulus.

Figure 5.

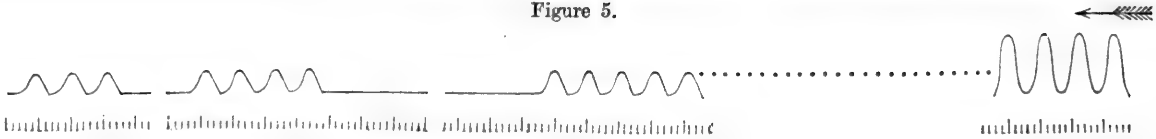
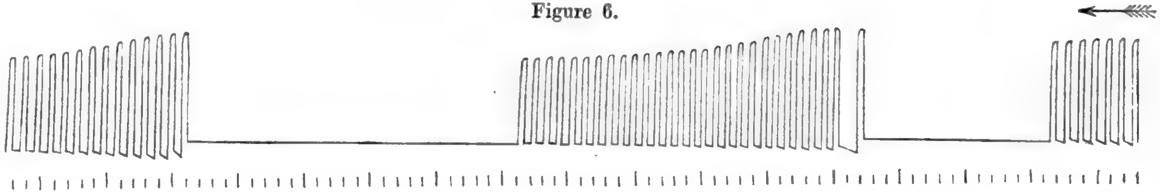
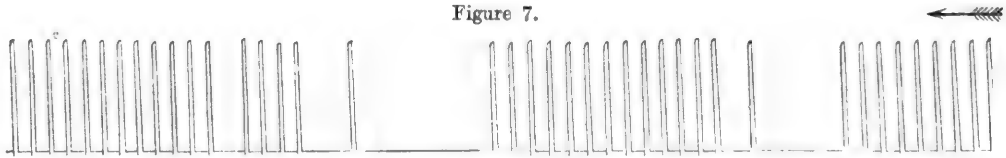


Figure 6.



Stimulation in intervals of 5″. Each line corresponds to an opening induction-shock.

Figure 7.



Ventricle of frog's heart stimulated at intervals of 5″ with opening induction-shocks of equal intensity (14 units), whilst the temperature of the serum-bath varied between 15° and 18° C.

In serum heated to about 25°C. the heart appears to reach the maximum of its mobility. Heated more strongly it becomes less sensitive; if cooled, however, it may again recover its high susceptibility for stimuli.

If the temp. of the ventricle is raised to 42°, it becomes rigid, loses its irritability completely and for ever. (Fig. 9.)

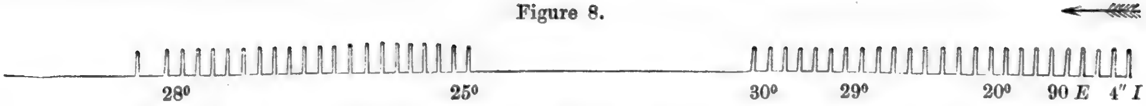
If a cold heart is warmed rapidly it may pass into lethal heat-tonus even at 30°. In what way the pulse-curve of a warmed heart differs from that of a cooled one, first Cyon (*Arbeiten aus der phys. Anstalt zu Leipzig*, 1866, p. 101), and later Luciani (*loc. cit.* p. 166), sufficiently investigated. A fresh, warm (23°—27°) heart contracts very rapidly and equally; its dilatation occurs so suddenly that the column of mercury sinking in the manometer, not being hindered by the resistance of the wall of the ventricle, passes with considerable rapidity the position of equilibrium, and now "over-stretches" the cardiac muscles, just as Kronecker has observed in the muscles of the skeleton (*Ludwig's Arbeiten*, 1871, p. 252). The beats of a heart cooled to 15° are lower and slower. If the temp. falls to 10°, not only does the pulse-wave become flatter and longer, but weak stimuli lose their infallibility. *The heart's beat becomes constantly irregular.*

Only every second stimulus meeting the ventricle in intervals of 4″ or even 5″ is replied to. Stronger shocks cause isorhythmical beats; these again give way to the rhythmus ½, when the heat is further diminished. Even now considerably increased strength of stimulus can also produce continuous beats, but only for a short time.

In the stimulating tempo of 12 per minute the heart willingly reacts to each second weak shock (30 E), even when the temperature has sunk to 5°. The beats are thereby not so flat as when the cold heart is forced to an unusually high pulse frequency. With the temperature, the height and steepness of the wave increase. At 11° and 12° the beats regain the rhythm of the stimuli.

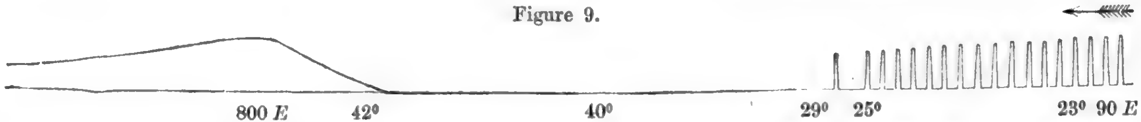
The above results leave the question open, whether the cooled heart makes a contraction after every second stimulus, because it requires two summed impulses, or whether the first stimulus only passes away without effect, because it finds the

Figure 8.



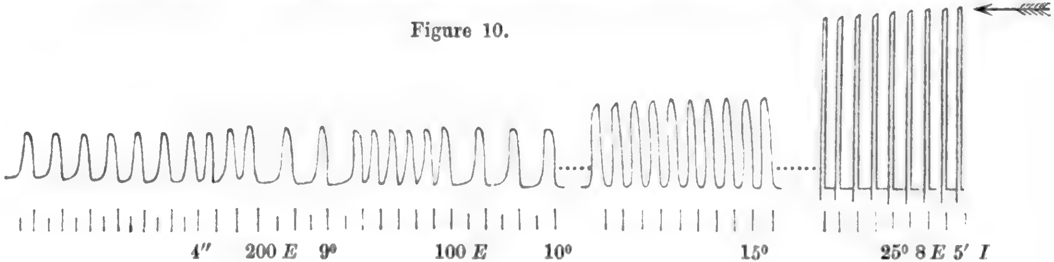
Frog's ventricle stimulated in intervals of 4″ with opening induction-shocks of equal intensity (90 units), whilst the temperature of the serum-bath was varied between 20° and 30°.

Figure 9.



Frog's ventricle stimulated at intervals of 4″ by opening induction-shocks of 90 *E*, whilst the bath was warmed from 23° to 42°. At last, during the heat-tonus stimulation by currents of 800 *E*.

Figure 10.



Ventricle of frog's heart cooled gradatim from 25° to 9° C.; at first stimulated by weak opening induction-shocks (8 *E*) at intervals of 5″, later by strong shocks (100 to 200 *E*), latterly at 4″ interval. Each mark corresponds to a stimulation.

sluggish organ not yet ready to beat, but that the second stimulus is itself active.

We have seen that we succeeded even with weak currents in producing half the number of beats, and that regular results were first obtained by very much more intense shocks. This seems to render probable the second of the above cited possibilities. On the other hand, however, we saw also that by more rapid time of stimulation (4″) every second shock was followed by a beat. This seems to speak for the first alternative.

The second view is supported by the following, the result of many observations. The cooler the heart becomes, the slower are its movements, the more seldom are the beats which it tends to produce. *If the contractions of the heart are desired in intervals of time which are greater than the pulse-periods corresponding to its present condition of mobility, then comparatively weak stimuli produce infallible contractions; if moderate stimuli meet the heart before it has completed its pulse-period, then they remain without effect.*

For a cold heart therefore whose pulse-period is longer than 5″ it is quite the same whether it is stimulated at intervals of 5″ or 10″; it contracts every 10″; *i.e.* at every impulse, or at every second, according to the frequency of the shocks.

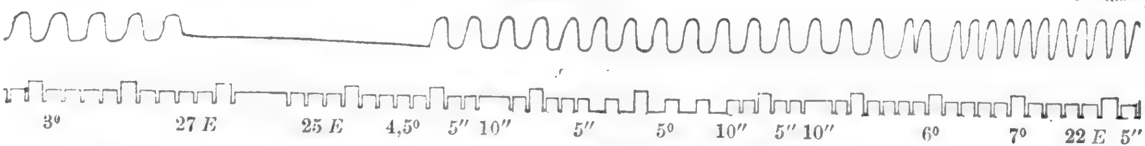
If we employ minimal stimuli, then it is to be observed that the afore-mentioned diminution of excitability with the temperature always falls below the formerly observed limits. Stimuli which were previously adequate become ineffective. With the induction-shocks made stronger, every second produces a beat.

It scarcely requires to be remarked that the different strengths of the current which are infallible for different hearts, vary very much; just as the strength of the current employed was not from experiment to experiment constant, because the two Grove's elements in the primary circuit of the induction machine were not filled with fresh acid before each experiment, *i.e.* did not always produce currents of equal intensity. Only the relations of the strength of the stimulus during an experiment are to be regarded as constant, and are tolerably exactly defined by the current-units. To give an idea of

Figure 11.

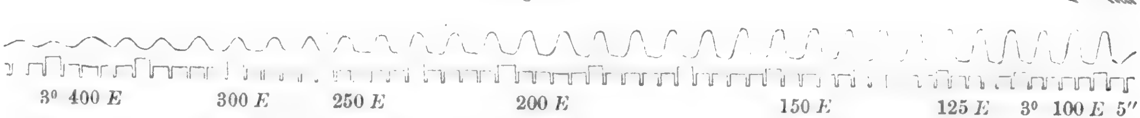
Ventricle of frog's heart stimulated by opening induction-shocks of 30 *E*, at intervals of 5″. Each mark corresponds to a stimulus. The serum-bath warmed from 5° to 12°.

Figure 12.



Ventricle of frog's heart cooled from 7° to 3°, stimulated with opening induction-shocks (22 *E* to 27 *E*) in varying tempo from 5″ to 10″.

Figure 13.



Ventricle of frog's heart cooled to 3°, stimulated at intervals of 5″ with induction-shocks of 100 to 400 *E*.

the absolute strength of our current-units, it may be stated, that 1000 units represent the maximum intensity of an induction-current which can be obtained from the largest (secondary spiral 11,000 turns) induction-machine armed with two Grove's elements, and that our apparatus gives induction-shocks of 70 units, when the beginning of the secondary spiral stands at the end of the primary.

The same heart which gave the original for Fig. 12, executed when cooled to 3° the curve shown in Fig. 13, and continued to retain its beating-tempo of 6 per minute, although the stimuli were increased to double the frequency and to quite an extraordinary strength. Strong induction-currents so injure the ventricle, that its beats soon become very flat.

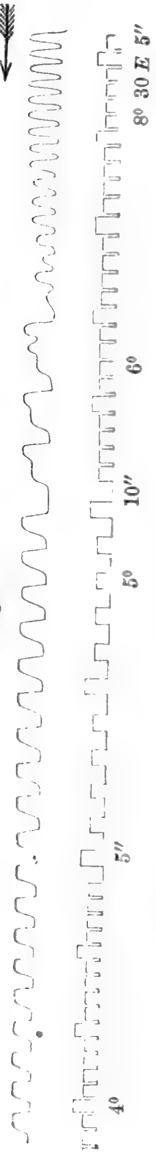
Sometimes a ventricle which has been rapidly cooled, and which cannot follow the tolerably strong stimuli, passes into convulsive contractions, interrupted by periods of rest, which present quite the appearance of dicrotous and tricrotous beats, and with measured moderate stimulating-tempo resolve themselves into regular, more seldom single beats. These then remain, even when the stimuli again reach the former frequency.

If the temperature is lowered to near 0°, the heart frequently reacts first at the third of the stimuli given in intervals of 5 seconds. Of the stimuli applied every 10 seconds, it replies to every second; by stimulation at 15 seconds interval, to every one.

Seeing that in this case the duration of an extraordinarily slowed cardiac contraction does not exceed more than about 8 seconds, one must assume that the cooled heart is not, at once after completing a contraction, capable of again contracting, or, to keep to our former simile, that a vibration of a molecule displaced from its equilibrium in the cold semi-fluid mass lasts longer than the visible movement.

In order to discover the pause necessary for the heart between the beats, or in other words, to find the pulse-rhythm adequate for it, one can either seek for the interval between the stimuli which just acts as infallible, or stimulate the heart with so rapid successive stimuli, that the duration of the interval does not come into count, and estimate the frequency of the beats.

Figure 14.



Ventricle of frog's heart cooled from 8° to 4°, stimulated with opening induction-shocks of 30 *E* at intervals of 5″ and 10″.

Figure 15.

Ventricle of frog's heart stimulated with opening induction-shocks at intervals of 1 second. Originally in a serum-bath of 8° to 5°. Strength of stimulus 500—800 *E*.—Later warmed to 30°. Strength of stimulus 15 *E*.

If strong, relatively very frequent stimuli (1″ interval) are applied to a pronouncedly cooled frog's ventricle, then it beats in rapid, frequent, quite regular tempo (10—9 times per minute), and in this way, that it only responds to every sixth or seventh stimulus. Considerably warmed (20°—30°) it willingly follows even weak stimuli in accelerated tempo (1″), even when this does not permit it to complete its diastole.

If the intermittent stimuli, which are produced by an induction-machine, provided with a Wagner's (Neeff's) hammer, vibrating rapidly and regularly, are allowed to act on the ventricle, then we obtain results which vary with the strength of the stimulus and with the temperature. A very excitable heart (warmed above 20°), stimulated with moderate stimuli, begins its activity at once with a single systole corresponding to its energizing power, the systole remaining only a little longer on the height than an isolated one of a similarly warmed heart. It then relaxes a little, to produce afterwards a series of very frequent, incomplete pulsations, which gradually show more effective diastole.

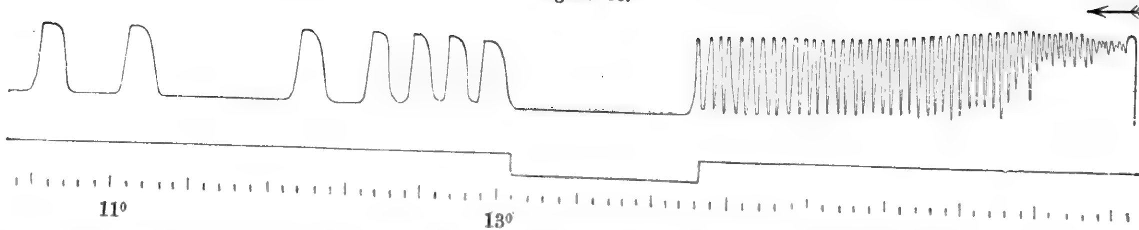
If the stimulus is allowed to act for many minutes together, the beats become separate, at last distant, irregularly grouped together, of course simultaneously lower, and this the quicker the more frequent they are. Weak stimuli have immediately at the beginning the same effect as strong ones during the series.

The moderately cooled heart reacts to middle strong stimuli at one time with a series of very seldom beats, which correspond exactly in form and size to those obtained by single stimuli from analogous hearts.

If the considerably cooled cardiac apex is exposed for a length of time to tolerably strong stimuli of a tetanomotor, it remains after a few sluggish contractions at rest. If, however, we allow it a short time to recover after a moderate period of stimulation, then it reacts at the beginning of each new period of stimulation with single, or may be, with dicrotous beats. If the heart is thereafter warmed, it again gradually regains its former excitability, and executes a series of very frequent incomplete beats.

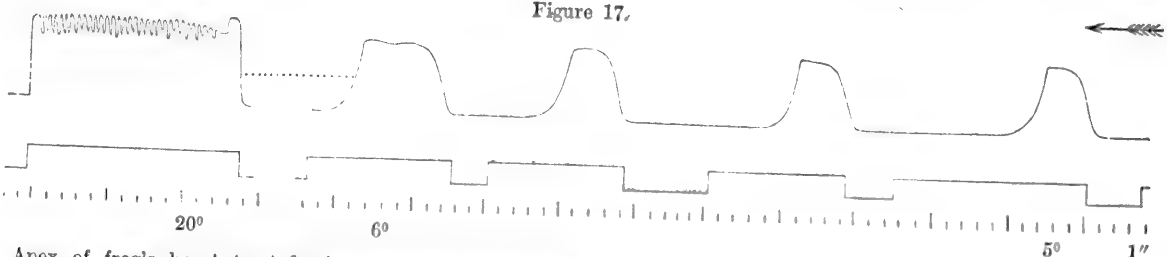
Alternating induction-currents of as great intensity as could

Figure 16.



Apex of heart of a large frog stimulated with frequent, moderately strong alternating induction-shocks. The lowest line marks the time (seconds). The middle line indicates by an elevation the beginning, by a depression, the end of a period of stimulation. The temperature of the serum-bath during the first period was 29°, during the second 13°—11°.

Figure 17.



Apex of frog's heart treated with alternating currents of a tetanomotor. After stimulation of 8″—12″ duration, it was allowed to rest for 3″—5″, whilst it was gradually warmed from 5° to 6°, lastly to 20°.

be obtained by our arrangement, do not cause the fresh heart (not cooled) in connection with our apparatus to execute higher contractions than the weaker stimuli, but, on the contrary, the curve diminishes from the first systole, as was to be observed in the formerly figured heart-curves. From this low level (frequently one-half of a single beat) the jagged curve sinks considerably, with a longer period of rest it becomes more toothed, till at last incomplete beats clearly appear and gradually separate into complete ones. The curves of the strongest stimulation by alternating currents are tolerably analogous to each other, whether the heart has its ligature under the sulcus or higher, whether it contracts at a moderate temperature of the room, or heated to 30°. If it is cooled below 15°, the curve obtained under such conditions assumes a form similar to those of the moderately stimulated heart. The apices of the systoles become broader with diminishing temperature, corresponding quite in form to single beats executed soon afterwards.

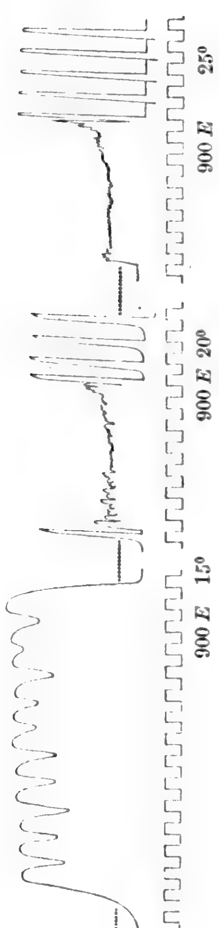
The pieces of curve copied in Fig. 18 are taken from the tracing of a ventricle, to which a part of its auricles was still attached, washed out with bloody solution of salt, and which pulsated spontaneously and rhythmically. (Compare Rossbach, Ueber die Umwandlung der periodisch aussetzenden Schlagfolge des isolirten Froschherzens in die rhythmische. *Berichte d. math.-phys. Cl. d. k. sächs. Ges. d. Wissensch.* 1874, p. 197.)

If the heart is observed in a transparent bath during the strongest stimulation, tumultuous peristaltic movements of the ventricle are to be observed, in the manner which R. Heidenhain (*Müller's Archiv,* 1858, p. 493) has described. This investigator, however, "sah in manchen Fällen den Ventrikel in eine vollkommen stetige, tonische Contraction gerathen, in einen exquisiten Tetanus."

Eduard Weber also (Article *Muskelbewegung* in Wagner's *Handwörterbuch d. Physiologie,* Bd. III. Abt. II. p. 35) had already observed that the heart by means of the rotation apparatus could be thrown into a continued tonic spasm, from which it gradually returned to its rhythmical movement.

Ludwig on the contrary, and in unison with him Eckhard, avers, that the heart in its entirety cannot be tetanized. Under

Figure 18.



Frog's heart, with a ligature round the auricle (pulsating rhythmically), washed out with blood solution of salt, stimulated with the strongest induction shocks (900 *E*). Salt-water bath at various temperatures. The line below indicates seconds.

the influence of the electro-motor the cardiac beats become greatly accelerated, "but every single beat is so weak, that in spite of its innumerable beats the heart becomes more distended, till at last it stands still. In this way it is easy to kill an animal." (*Lehrbuch d. Physiologie d. Menschen,* Bd. II. 2. Auflage, pp. 91 and 92.)

Goltz supports the view of the existence of a "true cardiac tetanus" (*Virchow's Archiv,* Bd. XXIII. 1868, p. 493). He says: "Verlangt man von dem Herztetanus, dass er die chronisch gewordene normale Form der Systole darstellt, so durfte allerdings den längst bekannten Formen von Tetanus ihre Legitimation als solche bestritten werden...", for in consequence of electrical or mechanical stimulation, "one scarcely ever observes an actual absolute quiet condition, but generally one observes here and there irregular fibrillar contractions." "Nevertheless, all these forms, according to my view, represent an actual genuine tetanus, caused by stimulation of the central organs, and their irregularities are sufficiently explained by the inequality of the stimulus employed," *loc. cit.* p. 496. "It has often been thought that tetanus could be produced by increasing the frequency of the pulsations. It was hoped that a condition would be reached in which the change from systole to diastole would no longer be obvious and that a continued systolic spasm would be developed." "I hold this conception as erroneous. The tetanus of the heart occurs at once as a tonic equal spasm, which is capable of an increase to the most complete fixation in the most extreme contraction. After cessation of the extreme tetanus there is not enormous frequency of the rhythmical movements, but solely increasing difference in form between the systole and diastole with normal tempo." "The long sought for method, to produce a general equal tetanus of the ventricle, corresponding to a chronic normal systole," consists, according to Goltz, in this, that the ventricle of the frog's heart temporarily be over-distended, 'übermässig', and powerfully so by means of the blood forced into it."

In Fig. 9 we have already seen a long tonic cardiac contraction produced by strong heating. Such heat-tetanus has also been described by Luciani (*loc. cit.* pp. 171 and 172), and before him also was observed by many physiologists. Similar contractions are sometimes exhibited by a frog's heart poisoned with atropine, without its being essentially injured by such spasm (*loc. cit.* p. 188, Fig. 36). Beats follow, whose diastoles are at first incomplete, but gradually appear quite perfect. Even frogs' hearts washed out with fresh arterial blood sometimes pass spontaneously into tonic spasm (Rossbach, *loc. cit.* p. 200).

Are we justified in characterising all these conditions by the name of tetanus?

E. du Bois-Reymond first introduced "*Tetanisirung auf electrischen Wege,*" (1842), into the investigation of muscular contraction, as a means "of securing the evanescent character of these phenomena, in order to obtain explanations, incapable of being obtained from a single contraction" (*Untersuchungen über thierische Electricität,* Bd. II. p. 39). Ed. Weber succeeded (1846), with the aid of a magneto-galvanic rotation apparatus, "in producing for a long time continued muscular contraction and in equal completeness, as we see arising in a natural way through the influence of the will, or in rigor mortis." "If the galvanic shocks which one communicates to a muscle or its nerve are allowed to follow each other so rapidly that the muscular contractions thereby produced, in spite of their short duration, are linked to each other so completely that the next following one begins before the previous one has ceased, then the contraction of the muscles becomes so lasting and so complete, that not even with the microscope can movements or quiverings of the individual muscular fibres during its continuance be detected." "But we can also produce continued contractions of muscles by other means than the galvanic apparatus, *e.g.* by mechanical stimuli, provided that the actions producing the contractions follow each other with sufficient rapidity" (*loc. cit.* pp. 11 and 12). E. du Bois-Reymond defines tetanus in the following way: "Tetanus produced electrically is discontinuous." "The continually produced contractions of the second (secondarily excited) muscle, every contraction of which must correspond to a variation in the current of the first, show that the apparently ever so constant contraction consists of a disconnected series of frequently recurring, exceedingly rapid actions."

"It is on the whole questionable whether an apparently constant contraction is actually of this nature or not, like the electrical, composed of a series of momentary actions rapidly following each other. It is to be assumed that even with the most rapid turning (of the interrupting wheel) a shock may correspond to each closing and opening of the primary current, like an induction current (*loc. cit.* Bd. II. p. 89 and 90).

This view is supported by Helmholtz (*Müller's Archiv*, 1850, p. 277), and he regards "continued contraction of a muscle as a series of simple contractions following each other so rapidly that each previous one at the appearance of the following has not perceptibly relaxed." Later, he enunciated the law by which tetanic shortening follows the summation of single contractions (*Monatsberichte d. Berliner Akad. d. Wissensch.* 1854, June).

From the above, it is clearly shown that the founder of muscular physiology wished to designate with the name tetanus (from analogy with the tetanus of disease) a condition of muscle which is kept regular by the superposition of a number of shocks. The absolute duration of the contraction does not distinguish whether it is to be regarded as simple or tetanic, but the experimental analysis into single contractions. We cannot be in doubt that a contraction of a gastrocnemius of half a second's duration is tetanic, as soon as we can prove that it is higher and longer than one of the simple contractions whose rapid succession had made it continuous, or that it produces on a normal muscle a secondary tetanus whose duration is greater than that of a simple contraction. Contractions however such as are given by strongly-cooled muscles (Marey, *Mouvement dans les fonctions de la Vie*, 1868, p. 346), or muscles poisoned with veratrin (Fick and Böhm, *Arbeiten aus d. physiolog. Laborat. d. Würzburger Hochschule*, 1872, p. 154), with a duration of half a second or longer, we must regard as simple, because we cannot prove the "oscillatory character" of the same.

The heart's beat is shown, by means of the physiological rheoscope, to be a simple contraction (Kölliker and H. Müller, *Sitzungsberichte der physiol.-medicin. Gesellsch. in Würzburg.*

Bd. VIII. Heft ii. 1856. Marey, *Journal de l'Anatomie et de la Physiologie,* 1866, p. 403). Under the influence of cooling one may observe that the duration of the contraction of the ventricle of a frog's heart may be gradually lengthened from half a second to five seconds. The long contraction of the sluggish cold heart is at the same time very low. Why should not poisons, just as extreme electrical, thermal and mechanical stimuli, also abnormally lengthen the contraction, without this having therefore to assume the character of tetanus?

The graphically represented heat-tetanus (Fig. 7) and the maximal height of such contractions indicated by Luciani (*loc. cit.* 171 and 172) do not reach the height of simple beats; just as the maximal value of the elevation which Luciani observed to occur (*loc. cit.* p. 188), after poisoning with atropine, remains below the previous and following contractions. Schmiedeberg (Ueber die Digitalinwirkung am Herzmuskel des Frosches. J. Schmiedeberg, from *Beiträge zur Anatomie u. Physiologie, als Festgabe Carl Ludwig von seinen Schülern,* Leipzig, 1875) communicates a fact which is calculated to strengthen in a very substantial manner the proofs against the existence of cardiac tetanus; digitalin throws the heart into contraction, which is however only lasting because the changed aggregate condition of the heart renders its distension more difficult. The poisoned ventricle conducts itself like an excessively fatigued muscle, "which preserves with dough-like toughness the form which it has assumed." (H. Kronecker, *Arbeit. aus d. phys. Anst. zu Leip.* 1871, p. 258.)

How then are to be explained the continuing contractions of the heart, which have been observed under the influence of alternating electrical currents, *i.e.* under the same conditions as the tetani obtained on the muscles of the skeleton?

E. Weber (*loc. cit.* pp. 35 and 36) observed that the heart of the frog, after it had been exposed for "several seconds" to the action of the strong currents of the rotation-apparatus, "gradually contracted and continued so," "so that the contracted parts (around the nearly-approximated electrodes) took no more part in the rhythmical movement." The stimulated part of the heart "continued also after interruption of the current for a *long time* completely motionless, and only very late and very gradually did the rhythmical movements return, the tonic spasm lastly disappearing."

Hoffa and Ludwig (*Henle and Pfeufer's Zeitsch. f. ration. Medicin*, 1850, p. 129) remark that "the most powerful electrical stimuli are unable to throw the heart into general tetanus." With very excitable hearts "a small pale elevation" forms between the electrodes placed on the heart. "Beyond this point the heart passes into extraordinarily rapid quite irregular movements of very slight intensity." "The individual anatomical elements separate in their relations one to another and cease to contract simultaneously. Hereby a complexity in relation to rhythmus and intensity is produced......during which the heart becomes pronouncedly larger and fills with blood. These movements always lasted longer than the stimulus, and this the longer the stimulus was allowed to act." "Lastly, more and more parts cease their rapid movements and pass into the condition of complete rest; when the pause has become general, and after it has lasted a short time, there suddenly arises a powerful general movement of the heart, which again begins the rhythmus."

"By the gradual passage of the electrodes over the whole organ one can extend the intrapolar condition over the whole heart (*loc. cit.* p. 131). Rossbach calls this change a "shrivelling" ("Schrumpfung") (*Verhand. d. Würz. phys.-med. Gesellsch.* N. F. Bd. v. p. 189), which "appears immediately as an after effect of local, mechanical, or electrical stimulation of the ventricle of the frog's heart." "This shrivelled part shows no more activity and is completely robbed of its vital properties." It happens only to the muscular fibres immediately affected by the stimulus. Similar results are to be observed on hearts poisoned with ecbolin (*loc. cit.* Bd. VI. p. 24).

A different explanation is given by Heidenhain in *Müller's Arch.* 1858, p. 493, of his essentially analogous results on the electrified frog's heart. Intense induction-currents of the magnet-electromotor brought the ventricle into "a vibrating, quivering, heaving movement," which Heidenhain would represent "as a tumultuous tetanus." "In many cases he observed the ventricle pass into a complete continuous tonic contraction, into an exquisite tetanus." He therefore cannot assent to the assumption of Eckhard that the heart knows no tetanus.

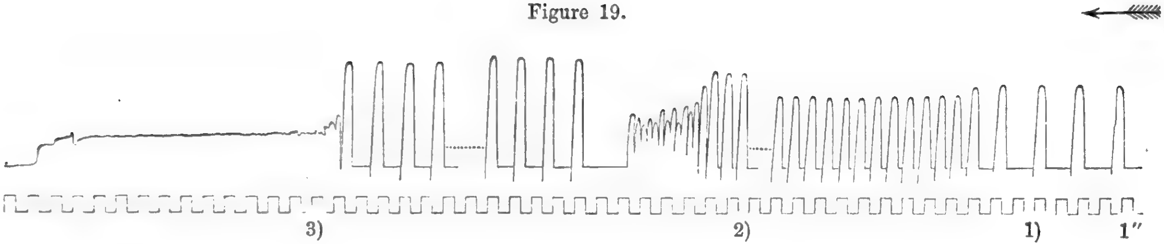
The graphic method which Ludwig introduced also into this province of physiological investigation (*Arb. aus d. phy. Anst. in Leipzig*, 1866, p. 80), gave us the means of measuring the mechanical effect of the contraction of the isolated heart. Then was one first able to decide, what from mere observation of the organ could only be guessed at, that the so-called tetanic cardiac contraction raised the column of fluid in the manometer to *a less* height than the simple beat.

The cardiograms of frogs' hearts stimulated with alternating currents show, that (1) just in the same measure, as by weak effective stimuli the frequence of the beats increases, so the heights of the beats become smaller; (2) under the influence of moderately strong stimuli the very frequent beats run together incompletely, but do not, like the contractions of incompletely tetanised muscles of the skeleton, sum up their mechanical effect, but are able to support the column of fluid only at the height of a simple systole, frequently even below this, within varying limits; that, lastly, (3) the cardiac delirium which is produced by the strongest currents communicates many small, but only weak, impulses to the float of the manometer, so that it remains quivering at a height above the diastolic position. The movement ceases at once with the stimulus, and after a period of rest, from one second to a minute, the heart begins again to beat in the ordinary manner.

The appearance of a curve, written by a moderately excited heart, reminds one forcibly of the figures which Kronecker (compare *Die Gesetze d. Muskelermüdung, Monatsb. d. k. Akad. der Wissensch. zu Berlin*, 1870, August, p. 639) sometimes (in winter) obtained from lightly-weighted (20 grms.) still non-fatigued muscles, which, stimulated in moderate intervals (4″), produced maximal contractions. Such muscles, during the whole time between two series, remain somewhat contracted, in rare cases even at the highest point of a simple contraction. Stronger weighting (40 grms.) overcame the tonus, which again became obvious, as soon as the surplus weight was removed. With increasing fatigue this peculiar phenomenon disappeared.

The objection, that it is only the irregularity of the tetanic

Figure 19.



Heart of frog with auricular ligature, at the temperature of the room (about 20°), stimulated (1) by weak alternate currents, (2) after new supply of serum by middle strong, (3) by very strong currents. Every tooth and every space in the lower line correspond to 1″.

contraction which conceals the collective effect, even contains the concession, that the contraction of the heart is not analogous to that of a muscle of the skeleton, whose individual fibrillæ do not contract non-simultaneously when tetanising stimuli are applied to the whole organ. The view of Goltz (*loc. cit.* p. 494), however, that the "fibrillar, irregular contractions" of the continually electrified heart "represent an actual, genuine tetanus, caused by stimulation of the central organs, the irregularities of the tetanus being sufficiently explained by the inequalities of the stimuli employed," we cannot admit to be correct; for we have seen that the ventricle of the heart cannot be brought to a constant tetanus, even when, instead of electrodes placed upon it, regular equal alternating induction-currents are passed through the fluid which bathes the heart within and without. What electricity cannot do, cannot be accomplished by other means of stimulation. Of the poisons, strychnine, which throws the muscles of the skeleton into reflex tetanus, delphinin (Weyland in *Eckhardt's Beitr. z. Anat. u. Phys.* Bd. v. 1870, pp. 51 and 68), which so acts upon the muscles that a momentary stimulus produces long-continuing tetanus—the former does not stimulate the heart at all (Hoffa and Ludwig, *loc. cit.* p. 132), the latter causes irregular pulsations (Bowditch, *loc. cit.* p. 169).

The violent mechanical stimulus, which is caused by blowing up the heart, appeared to Goltz (*loc. cit.* p. 493), as already mentioned, fitter to produce a true cardiac tetanus, and its author maintains, "that it represents the chronic normal form of the systole, and that after a certain time it permits the return of the normal condition." That the terms 'long contraction' and 'tetanic contraction,' according to the generally adopted physiological technology, are not synonymous, has been already sufficiently pointed out. Here it is only necessary to mention, that the simple contraction of a stretched muscle of the skeleton is much longer than that of a normal muscle (Marey, *Mouvement*, p. 363).

It is necessary to prove a series of observations which can be included as an important proof of the existence of "cardiac tetanus," the complex movement described by Luciani (*loc. cit.* p. 24) as "tetanischer Anfall des Herzens," which is exhibited by the isolated frog's heart, when a new ligature is placed round its auricles, whilst its contents (rabbit's serum), communicated by means of a cardiac-cannula with the mercurial manometer. The "effect of the act of ligaturing" consists in an immediate elevation of the column of mercury, often twice as high, sometimes four times as high as the previously marked beats (*loc. cit.* p. 25). At first, on the height very frequent and small beats are written by the float, the beats gradually become more seldom and larger, whilst the pressure sinks to the original value. "Several times the periods were to be observed during the course of a tetanus curve, so that single contractions alternated with pauses, whilst the tetanus curve followed its continuous course" (*loc. cit.* Fig. 11). "The duration of the tetanus was sometimes a few seconds, more frequently several minutes, with equal and regular decrease of the curve to the abscissa." The height of the tetanus is the more pronounced the nearer the ligature is placed to the ventricle, but stands in no distinct relation to its duration. "If the ligature is untied whilst the tetanus still continues, the pressure sinks at once to the normal value, the beats become again more numerous, at first still frequent, and gradually become more seldom, and at the same time higher. If now a new ligature is placed above the ligature spot, tetanus can no more be produced." Luciani remarks expressly that "the tetanus of the heart does not consist of single contractions placed one above another like an ordinary muscular tetanus." "The continual condition of contraction appears to be quite independent of the individual beats, and can be called a muscle-tonus in a certain sense of the word."

Dr Kronecker was at first inclined to accede to this explanation of Luciani, and that the more so, as he could obtain somewhat similar curves from the voluntary muscles upon throwing them into tonic contractions by strong constant currents, and applying single induction-shocks in rhythmical sequence to the corresponding nerves (Wundt, *Arch. f. Anat. und Phys. von Reichert u. du Bois-Reymond*, 1859, p. 549). The single contractions appeared upon the tonic curve. Upon our removing the membranous valve from the Mariotte's flask, and replacing it by the system of stop-cocks already described, the appearance of the "ligature-tetanus" altered in a manner which excited our suspicions. When he shut off the cavity of the heart completely by means of a stop-cock towards the pressure-vessel, so that the fluid could only pass towards the manometer, and now placed a ligature upon the auricle or ventricle, the column of mercury rose at once just as with Luciani, but it remained, after it had fallen only a little, at a high point until we opened the stop-cock, and slowly allowed the pressure of the Mariotte's flask to govern the whole system of tubes. From this it appeared as if the *continuing* elevation of the diastolic pressure lay in the arrangement of the experiment. The process could then be explained in the following manner: as soon as the ligature begins to tighten round the heart, systoles follow as frequently as possible, which empty the auricles and ventricles into the manometer. If now the loop is drawn tight round the auricles, the part above the ligature is no longer passable for the fluid streaming back during the next diastole. The thereby diminished cardiac cavity contains, in the condition of diastole, only a part of the blood or serum previously present in the larger section of the heart. The remainder, which must remain in the manometer, is therefore greater; the more the cavity of the heart is limited, the deeper the ligature is applied. The original tolerably rapid sinking of the manometer column could be explained by the assumption that the wall of the auricle, folded under the ligature, yields somewhat to the high pressure. If the ligature is loosened, the blood-pressure falls at once to the old level. The beats, which had become very small under the influence of the abnormally high pressure, became again larger. A new ligature close above the previously ligatured spot causes no new stimulus more. The fluid is distributed on both sides of the ligature; the tetanus does not appear.

This view of the peculiar increase of pressure is supported by Bowditch, whose views upon "cardiac tetanus" correspond essentially with the above. The reason why, in the experiments of Luciani, the diastolic pressure did not continue at the height, but by gradually sinking gave the impression of a slowly-sinking cardiac tetanus, must, in consequence of our new control-observations, be placed in the apparatus itself. The ingenious arrangement of the membranous valve, which during the short increase of pressure from the cardiac side was quite sufficient to shut off the Mariotte's flask from the manometer, was not sufficient to prevent continually the hydrostatic equilibrium between the manometer and the flask from being gradually restored. The distended membrane covered originally with its central part the orifice of exit from the flask. But "the membrane is at one part of the wall finely perforated" (*loc. cit.* p. 117), in order to render possible the access of the nutrient fluid to the heart. In the closed space filled with serum (*loc. cit.* p. 116, Fig. 1*a*) in which the valve was placed, no fluid could pass through the hole in the membrane, if an exit was not furnished somewhere, or the surrounding wall could be widened at one part. On all sides the space is bounded by rigid walls. Only the membranous valve itself, which closes the space above towards the Mariotte's flask, and below towards the manometer, is itself moveable. Rendered tense by virtue of the pressure in the manometer, it favours the exit of fluid through the puncture, in that it becomes less and less tense, and makes room in the valve-space for the drops coming from the side of the heart. Lastly, the outflow from the Mariotte's flask is free, and the equilibrium is restored in the whole system, exactly as suddenly occurs when the membrane is pressed down (Luciani, *loc. cit.* p. 131).

To this explanation of the "cardiac tetanus" there is opposed a deduction of Luciani, which is based upon observations on hearts which were ligatured apart from the apparatus, and thereafter brought in connection with the manometer, and which wrote a series of contractions whose extent increases gradatim. Such a series of beats he characterised as "aufsteigende Treppe" of the "Anfallsgruppe" (*loc. cit.* pp. 123 and 124). He regarded such a "treppe" as a masked tetanus. Now, in that the single beats which appear upon the sinking tetanus-curve always become larger, (and with opened valve the position of the abscissa is only estimated by the position of the pressure-bottle,) immaterial whether the heart on its being attached to the apparatus is contracted or relaxed, so the series of beats projected from the tetanus-curve to the abscissa represent a "treppe." At first, almost completely contracted, the heart cannot expel a sufficient amount of serum to close the valve and raise the column of mercury. "When, however, the tetanus, as it usually does, gradually yields, then fluid penetrates into the cavity of the heart under the pressure of the bottle, just in proportion as the yielding of the cardiac wall increases, *i.e.* as the (tonic) contraction present in it has diminished. If, while this occurs, a new stimulus to rhythmical contraction again returns, then the first of these stimuli will meet a heart filled with a small quantity of fluid, and therefore propel only a little into the manometer, whilst the following ones act upon a heart more and more filled, and accordingly will produce elevations of the mercury successively increasing in size" (*loc. cit.* p. 130). According to this, the systoles would only really increase, because the diastoles become deeper, and the process would have a certain analogy with the tonic condition which we have observed in mobile hearts, which, irritated by intermittent stimuli, contracted so frequently, that their diastoles remained incomplete; only that in this case the high point of the tonus did not exceed the highest point of the first systole.

After satisfying ourselves of the increase in pressure, and having seen that we could obtain an "aufsteigende Treppe," when we allowed the heart, shut off from the Mariotte's flask, to beat, we must look somewhere else for an explanation of the remarkable phenomenon.

Bowditch had already followed this carefully under very varying conditions, and showed that the ventricle of the frog's heart filled with rabbit's serum was distinguished from other transversely striped muscles, in that a contraction executed after a pause of some minutes, is not larger, but smaller than the previous ones. "Each (in intervals of several seconds) successive one increased in extent, in this way however, that with the increasing number of contractions the increase becomes smaller and smaller, till it at last disappears" (*loc. cit.* p. 156). From the maximum when reached, the "curve of fatigue" falls with its convexity directed towards the abscissa, and this the steeper the smaller the interval chosen between the stimuli (*loc. cit.* p. 161). The fatigued apex of the heart can, to a certain extent, be again strengthened by replacing the used serum with new serum. The energising power of the heart is lessened as well by long rest, as by continued work.

The remarkable discovery of Luciani, that a heart filled with serum, and ligatured round the auricles, executed spontaneously periodical groups of beats, and pausing for a time between these groups, afforded an opportunity of observing under varied conditions, the course of a series of beats after pauses of different durations. It was shown that the first groups of a simple ligatured heart, after pauses of one or more minutes, seldom show the "treppe," whilst the later groups on the contrary, or even those of a heart twice ligatured (*loc. cit.* Tables, p. 143, &c.), especially under the influence of a higher temperature, presented the phenomenon in a pronounced manner (pp. 163, 168, &c.). The treppe-like increase was never to be observed on the seldom pulse-groups of the cooled (4°—7°) heart.

If fresh serum is supplied to the registering heart after the effete stuff is removed, it is seen "that the beats within the groups become more numerous and frequent, that the medium height of the excursion increases considerably, that the descending 'treppen' fall more steeply, and the pauses become shorter" (*loc. cit.* p. 162).

The fact that the groups of the fatigued heart show the "treppe" unequally more frequently than those of the fresh heart, engendered the wish to test whether the changed serum in the heart diminished the productive power of the organ. Haller had already made the observation (*Element. Phys.* 1762, Tom. IV. p. 546) that the muscles of the skeletons, in which the blood has stagnated through ligature of the veins, become paralytic. If we assume that the heart decomposes its contents very rapidly, and that it suffers from the spoiled fluid, but is very easily restored by small quantities of fresh stuff, we can conceive that after long injurious rest the first small contraction expels some of the effete serum from the heart; that this is mixed in the glass tube with fresh serum, and of this, at the next diastole, new particles are brought in contact with the muscles of the heart, which being hereby strengthened renders the next high pulse possible, which again procures fresh material, until the mixture in the heart and the ascending tube has become tolerably uniform, and places a limit to further recovery. To prove this assumption we have sought to perfect the renewal of the contents of the heart, and for this purpose have employed the "double-channelled cannula" already described (p. 316).

The effect of such a method of transfusion, which permits of the heart being fed with a continual current of nutrient fluid, is of much greater importance, than was formerly supposed. We succeeded in obtaining beats, by means of bloody rabbit's serum, from hearts which had beat for a long time, and which had already become weak. The beats were higher than those of fresh hearts simply filled with analogous serum.

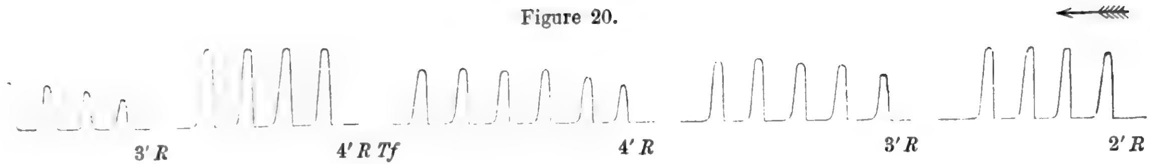
When we fatigued the apex of the frog's heart by successive rhythmical induction-shocks, then allowed several minutes rest, and then transfused serum or solution of salt mixed with rabbit's blood, the next stimuli caused beats, which were considerably higher than the last ones before the pause. The "treppe" disappeared sometimes completely. (Fig. 20.)

Old serum, used two days previously, but preserved in the ice-cellar, rapidly diminished the energising power of a heart filled with it.

The next figure illustrates the latter part of an experiment in which a heart's apex, after it had been periodically stimulated for several hours, and was almost completely exhausted (height of pulse 2,5 mm.), through transfusion (Tf.) of fresh rabbit's serum was again completely strengthened, so that the height of the beats rose to 13,5 mm., whilst the heart taken from the living animal and attached to the apparatus with the same serum wrote only 10,5 mm. high beats. (Fig. 21.) The "treppe" appeared now, by stimuli in 5″ interval, flat, ascending, after 1 minute's rest; short but distinct after 1,75′ rest, whilst serum was transfused through the heart; no longer after 2′ rest, whilst during the latter transfusion was performed; it appeared very markedly after 2′ rest, without transfusion.

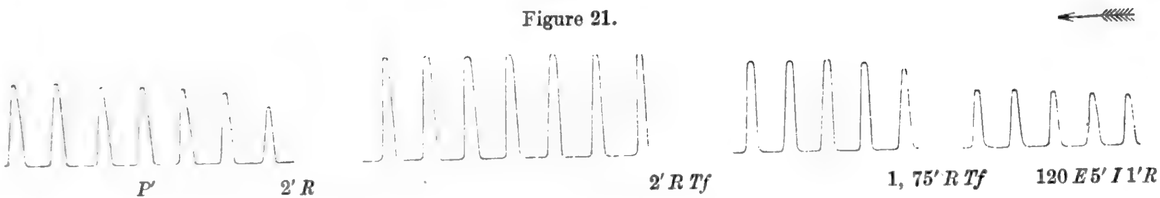
In warmed hearts (25°–30°) the serum very soon loses its restorative properties. After a short pause a distinct "treppe" appears. Still the heart recovers again very perfectly on fresh nutrient stuff being supplied; when washed out it regains during the pause the temporary maximum of its capa-

Figure 20.



Apex of frog's heart stimulated with opening induction-shocks of 60 *E* at intervals of 4″. Between short pulse-periods, periods of rest of 2 minutes (2′*R*), of 3′, of 4′ without transfusion; of 4′, during which a few cubic centimeters of fresh bloody serum were transfused (*Tf*); lastly, after a longer pulse-series 3′ rest without transfusion.

Figure 21.



Apex of frog's heart, stimulated at intervals of 5″ with opening induction-shocks, (1) after 1 minute rest (*R*) without transfusion, (2) after 1,75′ rest with transfusion (*Tf*), (3) after 2′ rest with transfusion, (4) after 2′ rest without transfusion, *P*′ marks a beat, which is as high as the first beat of the fresh heart.

bility of energising; no "treppe" being manifested. A fresh heart at the ordinary temperature of the room, as already shown, can without essentially suffering, tolerate serum for a few minutes (2), even when this is not quite fresh, but has not yet been used for circulation. The beats following in moderate intervals (5″) are then nearly equally high. If during a pause of 2′ the heart is washed out with bloody serum, then the next beats are considerably higher than those before the pause, and form a "descending treppe" ("absteigende Treppe"). (Fig. 22.)

This phenomenon corresponds to the result of Luciani. The first groups after the onset (Anfall) are characterised by the "descending treppe." Its most frequent form (with greater frequency of beats) is that of a curve which has its convexity directed towards the abscissa; sometimes it is completely or nearly a straight line (*loc. cit.* p. 141).

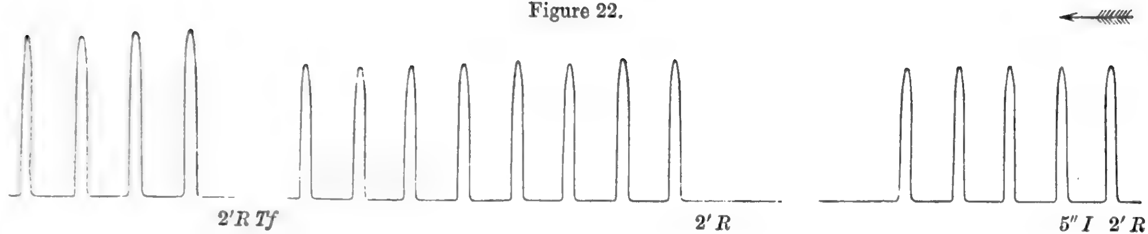
If on the contrary the heart is no longer fresh, but the serum fresh and nutritious, the current through the passive heart cannot cause the "treppe" to disappear, although it begins from a higher level than the "treppe" after a pause without a current. (Fig. 23.)

Frequently *one* beat in a richly nourished heart is sufficient to produce for the heart its maximum of energising power. After a short pause (half a minute), the next beats then appear descending without transfusion; but with a maximum height which is lower than that of the previous beats.

If we would explain the partial persistence of the "treppe" without transfusion, we must assume that the fresh nutrient fluid cannot expel the injurious fluid which accumulates in the muscular tissue, out of the *passive* heart, but can only accomplish this when these stuffs have been pressed into the cavity of the heart, out of the spaces, by the contraction itself. (Fig. 24.)

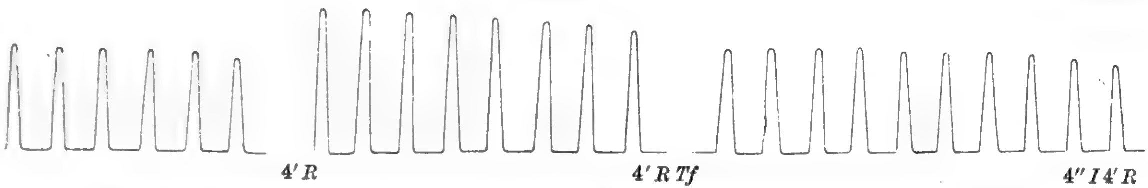
Our next task would have been to investigate at which period of rest the recovery of non-transfused hearts is greatest. This question however has been sufficiently answered in the case of the apex of the frog's heart filled with rabbit's serum, by the exact results of Bowditch (*loc. cit.* p. 160). From this experiment it is shown "that the highest elevation which the apex of the heart filled with fresh serum can

Figure 22.



Apex of frog's heart, filled with rabbit's serum preserved from the previous day, and diluted with a solution of common salt, stimulated periodically with opening induction-shocks (60 *E*) at intervals of 5″, (1) after two minutes' rest without transfusion, (2) after two minutes' rest without transfusion, (3) after two minutes' rest with transfusion.

Figure 23.



Apex of heart previously supplied with old, then with fresh serum; stimulated with induction-shocks (16 *E*) at intervals of 4″. (1) After 4 minutes' pause without transfusion, (2) after 4 minutes' pause with transfusion, (3) after 4 minutes' pause without transfusion.

accomplish, appears at an interval of between four and five seconds; if the interval is lengthened, the height of the elevation diminishes continually, until it, according to the individuality of the heart, with a pause of five minutes, reaches a minimum, below which even longer rest cannot diminish it; and not less does the extent of the contractions sink, when the interval is shortened from four to two seconds."

The fatigued muscle of the skeleton without the circulation conducts itself qualitatively similarly (*Ueber die Ermüdung und Erholung d. Muskeln, Arb. aus d. phy. Anstalt*, 1871, pp. 217 and 218). "The interval which permitted the maximum of recovery was three minutes. The maximum recovery is however not nearly so complete, when we take into account only the muscles of dead animals." The contraction in the example cited increases "rapidly with the interval increasing to 30 seconds, then lowers to 3 minutes, remaining nearly equal, when the periods of rest increase to 4 or 5 minutes, probably because after exhausting work death rapidly proceeds." Already C. Ludwig and Schmidt concluded from their investigations that in every stage of the fatigued muscle (a warm-blooded animal) there is in the course of its activity a diminishing maximum contraction reached by rest and blood, but which is not exceeded. It has also been shown that just as the amount of the possible capability of energising of a muscle diminishes with every new tetanic contraction, so in a similar manner the duration of resistance to want of blood diminishes with every interruption of the circulation (*Arbeit. aus d. phy. Anstalt zu Leipzig*, 1868, pp. 26 and 24).

We can now prove from the results obtained, whether it is reliable to regard the "treppe" as the expression of an increasing process of recovery.

We know that the beats of the registering heart become larger:

(1) When the nutrient fluid is renewed to a heart already fatigued (Hoffa and Ludwig, *loc. cit.* p. 135; Cyon, *loc. cit.* p. 89; Bowditch, *loc. cit.* p. 162; Luciani, *loc. cit.* p. 163).

(2) When short periods of rest increase. Bowditch showed this with the heart's apex stimulated electrically, and Luciani observed it in groups of spontaneous beats (*loc. cit.* Fig. 20, p. 141).

(3) When after a longer pause the heart begins again to beat, sometimes after injury:

(*a*) By mechanical violence (ligature). (Bowditch, *loc. cit.* p. 172.)

(*b*) By chemical lesions (treatment with muscarin and delphinin (Bowditch).

(*c*) By increased decomposition at higher temperature (Cyon, Bowditch, Luciani).

(*d*) By continued activity (Luciani).

All these results may be grouped together, regarded from one point of view; *the cardiac muscles can only act equally with the help of continually new nutrient material.* According to this (2) and (3) are subdivisions of (1).

Luciani regarded the "treppe" as a sign of diminished activity of contraction (increasing relaxation, if not as a sign of increased activity in the sense of diastole). The following results, however, speak against this view; one obtains the increasing series of beats, even when the heart, which has executed a "treppe," is completely shut off from the reservoir, and stands in connection with the manometer alone. If now the diastoles instead of the systoles increased, the heart must register negative pressures; or if it was not in a condition to aspirate, certainly no positive ones. That during most extensive diastoles, it sucks through its muscular walls fluid from the bath, in order to propel it into the manometer at the following systole, no physiologist can really believe; and whoever is inclined to do so, can easily convince himself that even without a serum bath the heart registers its "treppe" when it has a tendency to this mode of beating.

Bowditch was led by his experimental results to the necessary assumption "that during the pause between the contractions of the heart in opposition to the conditions, which (after short rest) increase the extent of the contraction, still other conditions arise which diminish the extent of the contraction." The extreme rapidity, with which the heart, even when filled with serum, in comparison with the muscles of the skeleton, loses its capability of energising, leads one to conjecture an extinguishing caused by nervous influence; and this view is confirmed by the fact that atropine, which is known as a poison which paralyses the vagus, can diminish the injurious influence of rest upon the heart.

On the relations of the atropinised heart during active circulation we have collected no results, still it is not impossible that this poison, in that it renders the tissues more lax, acts beneficially on nutrition.

Under such a supposition there is nothing to set aside the fundamental laws from which our experiment began; "that the reason why the apex of the heart contracts to different extents, is to be sought for in the changeable properties of the muscular fibre itself." Kronecker, in muscles of the skeleton excised from a winter frog, has observed a phenomenon analogous to the "treppe," for which the modification of irritability of Wundt cannot be made to account, in that, the stimuli employed were maximal (*loc. cit.* p. 204).

The knowledge which we have obtained in an analytic way has also been confirmed by us synthetically. If the heart is deprived of its nutrient material it rapidly loses its capability of energising, and regains it quite as quickly when it is fed anew.

If the blood or serum present in the cavity of the heart is displaced by non-injurious solution of salt (0,6 *per cent.*) *the beats sink very rapidly till they are not obvious; soon there remain only weak peristaltic movements; and lastly the heart stands still in diastole, quite incapable, even after the strongest stimuli, of executing the smallest movement. If the relaxed organ is thoroughly washed out with blood serum containing oxygen, it soon begins to make fibrillar contractions, then to beat feebly, until at last it works quite as powerfully as in the fresh condition.*

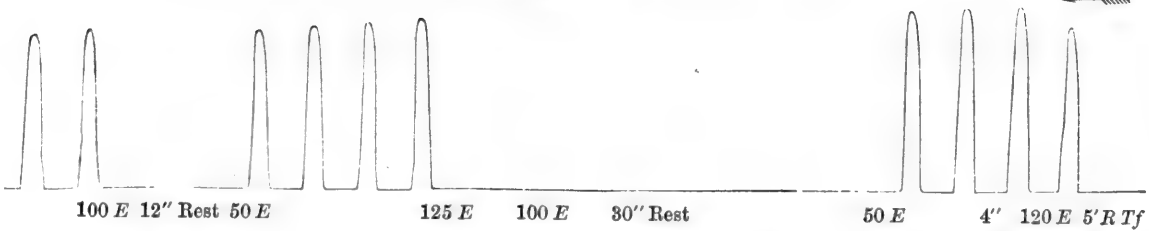
If after the heart has become empty of blood and seems to be dead, the system of tubes is filled with serum or bloody salt solution and the stopcock to the reservoir be closed, one may observe the most beautiful "treppe" arise. The negative picture of this process one cannot obtain so completely. When the heart containing blood is brought into connection with the system of tubes filled with pure solution of salt, the small amount of blood, in spite of its rapid dilution with the moved indifferent fluid, can preserve the heart capable of doing a moderate amount of work, for a considerable time. Every further transfusion diminishes the store and the production. Of course this result is valid quite as well for the artificially stimulated ventricle as for the spontaneously beating heart. Not only on the hearts of frogs (whose hearts, so long as they are sound and well, do not permit solution of salt [0,6 per cent.] to transfuse), but also on those of tortoises we have performed the experiment. The following three pieces of curves, obtained from the heart of a tortoise, may serve to exhibit the above formulated rule. The heart was provided with two cannulæ. The first one was tied into one of the cavæ and attached to the end of the system of tubes communicating with the Mariotte's flask; whilst the other cannula was placed in the aorta and in connection with the manometer end of the tubular system. So the heart took up the nutrient fluid into the right auricle through the vein, when the passage to the pressure-bottle was opened, and allowed it to flow by the aorta through the outflow-tube, or forced its contents into the registering manometer, when the outlet from the outflow-tube was closed. After the heart had been washed out for some time with bloody rabbit's serum it marked beats of which the first piece of Fig. 25, I, gives an example. After a short washing out with solution of salt it made contractions such as are given in the second group (II). When it was transfused for 1½ minutes with salt water the height of the beats (III) sank rapidly in irregular degrees, till they almost disappeared. (Fig. 25.)

Longer than 12 minutes, the heart showed fibrillar movements, whilst the level of the column in the manometer remained unchanged. After this, solution of salt mixed with blood (5 : 1) brought the beats again to their former height, and after this, pure solution of salt caused them to disappear. Afterwards, when the heart was again washed out with blood, it wrote off the curve copied in Fig. 26.

Two further small washings out with the bloody fluid brought the heart to continuing equable work. The beats, of which a series is figured in Fig. 27, II, are equal in height to the most powerful (sub. I. repeated) of the quite fresh heart. (Fig. 27.)

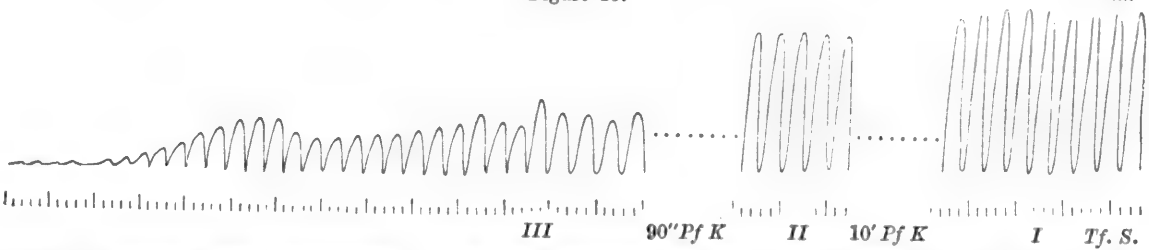
We have, therefore, four times completely extinguished the heart's capability of energising, by transfusion of an

Figure 24.



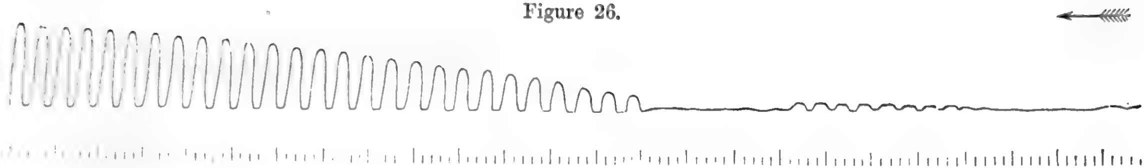
Apex of heart stimulated by induction-shocks of different intensities at intervals of 4′. Before the effective stimulation by 103 *E*, 5 minutes' pause, and transfusion with fresh serum; 50 *E* inactive, then 125 *E* effective, after this all stimuli to 50 *E*, then 100 *E* again. During the ineffective stimuli obvious recovery.

Figure 25.



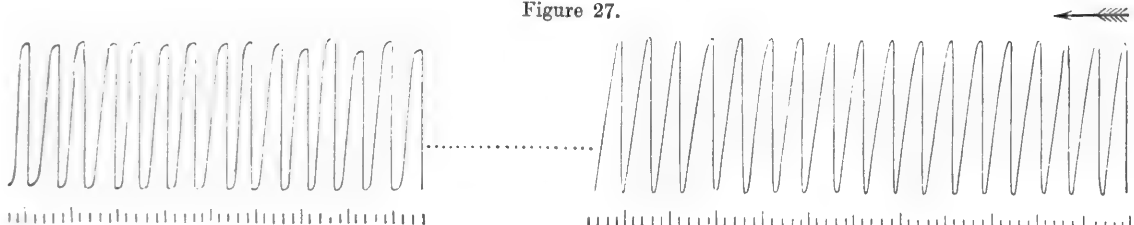
Heart of tortoise beating spontaneously. I. After long transfusion (*Tf*) with bloody rabbits' serum (*S*). After quite a short transfusion (10 seconds) with solution of salt (0·6 per cent.) (*K*). III. After longer circulation of (*K*). The lines mark seconds.

Figure 26.



Heart of a tortoise beating spontaneously. Column in the manometer caused to vibrate slightly by the transfusion, consequently the abscissa is not quite straight. I. Pulsation after 10″ transfusion (scarcely 1 C.C.) of 1 part blood (*B*) diluted with 5 parts salt solution (*K*) (1 ; 5). II. Pulsation *after* a similar repeated out-washing. The lines mark seconds.

Figure 27.



Heart of tortoise pulsating spontaneously. I. Fresh with bloody rabbit's serum (*S*). II. After more than 2600 beats, after 4 repeated transfusions of solution of salt (*K*) and quite as many transfusions with the mixture of blood. (*B*=Blood).

indifferent fluid, and equally as often completely restored it by the supply of blood. Astonishingly small quantities of blood are sufficient for this. A few cubic centimeters of a solution of salt, which contained about 0,5 per cent. of old rabbit's blood, brought the pulse-heights of a heart of a tortoise in a few seconds, from 0 to 12–14 mm., and maintained them for a long time as high. Thus it is explicable why excised frogs' hearts often beat for a long time without any new supply of material. The weak contractions require little expenditure. The weak cold heart acting under pressure conducts itself similarly, whilst the warmed one, rapidly exhausts its nutrient material by powerfully energising. In addition, the decomposition of the contents in the passive heart is accelerated by heat, and hindered by cold; therefore, in the first case, the restimulated ventricle begins its work with a steep "treppe," in the latter with a flat or almost invisible one. After these results it will not appear wonderful, that injections of solution of salt after transfusion of blood, often at the beginning have a restorative effect, although the system of tubes was previously freed from blood. The blood-corpuscles remaining in the cannula and the cavities of the heart itself, as above shown, are able to give back to the muscles of the heart washed out with a rapid current, a part of the material employed for work. If these residues, however, which sometimes remain longer in the trabecular work of the heart of the tortoise than in that of the frog, are removed by solution of salt, then the remainder of the force rapidly disappears. In this respect also, we find a resemblance between the heart and the muscles of the skeleton in which Kronecker "found the circulation of solution of salt completely indifferent before a highly productive transfusion of exceedingly dilute solution [0,01 per cent.] of permanganate of potash," whilst after the injection of the restorative ozone-carrier, transfusion of pure (0,5 per cent.) solution of salt, "showed such a small restorative activity, that one might ascribe it to the remainder of the permanganate of potash displaced from the supply-tube" (*Arb. aus d. physiolog. Anstalt zu Leipzig*, 1871, p. 183). Also on Plate IV. of that paper the minimal effect of a solution of salt circulating through a frog's muscle, in comparison with the action of blood, is represented from nature; on Plate v. complete inactivity of the neutral solution. Johannes Ranke reckons me wrongly, in the last edition of his *Physiology*, among the supporters of his doctrine of effete stuffs.

We have always till now silently presumed, that the recovery by blood-transfusion is due to an increase of the capability for energising, and not to an increase of the excitability. It is easy to prove on a ventricle not pulsating spontaneously, that the strength of the minimal stimuli by no means increases with the heights of the beats. With the same stimuli which the fresh, powerful heart requires for its great contractions, the salt heart, as a rule, continues to beat until its movements are extinguished. Strengthened stimuli do not help it—according to the fundamental law of the movement of the heart confirmed by our experiments—to increased energy. For a fatigued cardiac muscle, filled with old blood or serum, much weaker impulses are often sufficient to cause it to energise, than are necessary for the fresh heart. For the cardiac ventricle, already strongly fatigued, which yielded the curve given in Fig. 5, 46 units were sufficient to produce beats, whilst when it was strengthened by transfusion it required 120 units in order to write off the curve given in Fig. 24.

Bowditch also remarked that "in order to obtain a certain effect, it was not necessary to increase the intensity of the induction-currents, when the extent of the contraction was increased by muscarin, or the size of burden had diminished by fatigue." On the contrary he found that the susceptibility "was increased by a series of contractions" and diminished by long rest (*loc. cit.* p. 175). The meaning of this peculiarity we have already pointed out at the beginning of this paper.

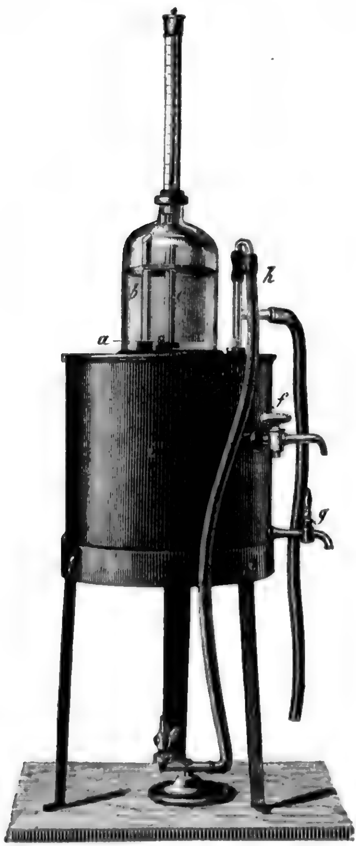
We have recognised the heart as an organ, with whose energising powers no manufactured machine can in the most remote degree be compared. So small in size, that a consumption of particles of tissue as the material for work—as many physiologists assert of the muscles of the skeleton—would completely consume it within a short time, it is almost immediately capable of energising as soon as it is nourished, and employs the forces at its disposal, in the most complete and most careful manner for work. It completely loses its property of energising as soon as it is deprived of food, does not nourish itself therefore from its own substance, but continues without wasting, when well nourished and not maltreated, for an unlimited length of time. Not every most gentle impulse is sufficient to cause it to act, but when it has once been set in action, then less powerful impulses are sufficient to continue its movement. It always works with full force, and in fitting tempo; little disturbed by untimely impulses, not at all affected by a change in the strength of the stimulus, as its destiny to constant regular exactions of relatively greater weights demands. Under the same conditions (heat), which increase the decomposition of the nutrient stuffs, the mobility of its parts increases. The external conditions (cold), which diminish metamorphosis, make it at the same time more sluggish. On the contrary, the heart is of little use as a reservoir. Even when at rest it extracts from the contents touching its walls, a part of their work-material, and is, therefore, at the beginning of its activity, not in complete possession of its capability of energising, without being supplied by new material.

DIGESTION-OVEN WITH A DIFFUSION APPARATUS[1].

By Dr Hugo Kronecker.

In the Chemical Laboratory of the Pathological Institute of Berlin, in the year 1856, under W. Kühne's direction, I made experiments on the digestion in the stomach, and tried to separate the stomach-ferment by diffusion from the peptones mixed with it. Graham's dialyser appeared to me to be inconvenient, and not easily kept free from impurities, and, further, was not suited to hold together the small quantities of gastric juice which I had at command—as

Fig. 1.



[1] From *Beiträge zur Anatomie und Physiologie als Festgabe Carl Ludwig gewidmet von seinen Schülern.* Leipzig, 1875.

I wished to compare the amount of pepsin contained in horizontal sections of the stomach of the pigeon made at different heights. My desire was to possess a dialyser, whose form gave the largest surface with small contents, and thereby remained free from constituents which are easily proved to contain impurities. Vegetable parchment and glass supplied the best materials. After many attempts in trying to make the diffusion-paper into tubes, the most simple and convenient form was found to be the folded filter.

If it is placed in a glass funnel, and is filled with the solution to be diffused, there only remains the task of keeping the outer fluid which should take up the diffused stuffs, at the same level as the fluid within. This was obtained at first by another vessel, which was united by means of a caoutchouc tube to the tube of the funnel, and allowed the fixing of the level of the diffusion-fluid. Later, the instrument was perfected in Leipzig.

The collective apparatus is intended to complete as rapidly as possible the digestion of a comparatively large quantity of nutrient material, to render the product of the same easily drawn off, and to retain the active ferment as undiminished as possible. For this purpose the following arrangement was found to be most effective, Fig. 1 gives a view of the whole apparatus.

A cylindrical tin vessel, *i*, 18 Ctm. in height, and 20 Ctm. in diameter, is filled with water, whose temperature must be kept constant by a temperature regulator, *h*. A brass stop-cock, *g*, renders the emptying the vessel more convenient. The lid has two openings. In the central one of about 9·5 Ctm. diameter there hangs a tubular glass, *e* (Fig. 2), 10 Ctm. in height and 9 Ctm. lumen, and held firm by means of margins bent out to 10 Ctm. in width.

The other narrow opening is for the mercury-vessel of the regulator.

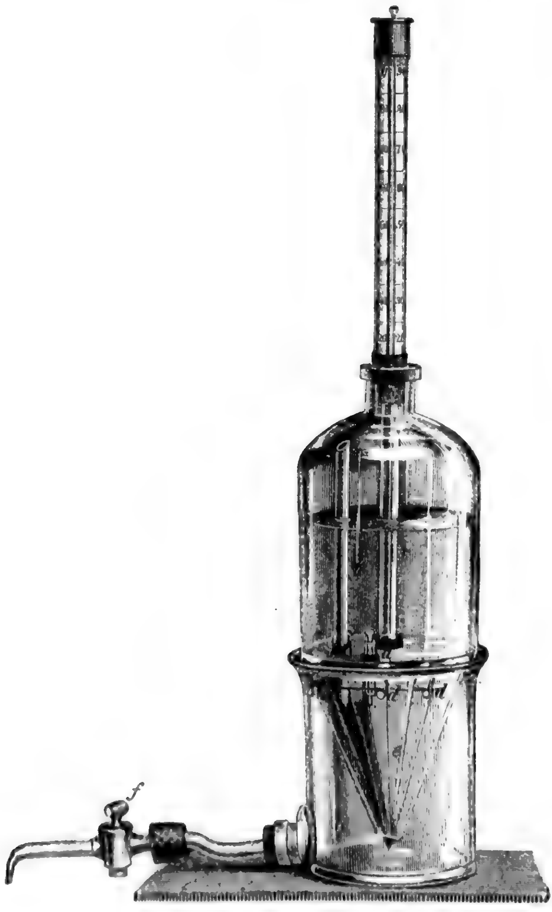
The outflow tube with the glass stop-cock, *f*, is fixed in the tube of the glass, and penetrates at *f* (Fig. 1) the wall of the digestive oven, and is kept water-tight by means of a cork.

In the glass is suspended an acute-pointed funnel with the tube cut off, and whose wall, 2 Ctm. below the upper margin, is perforated by a number of holes (*dd*) of the size of a farthing. In the funnel, Fig. 2, lies loose a folded filter of parchment paper, which reaches to the margin. The directions given by Wolffhuegel (Ueber Pepsin und Fibrinverdauung ohne Pepsin, *Pflüger's Arch. für Physiologie*, Bd. VII. 1873, p. 189) for the use of my dialyser are worthy of note; not to allow the folds to run to the apex, to avoid cracks, to moisten the paper previously, but to leave the upper margin of the filter dry, so that the inner fluid may not go over externally.

If it is intended to accelerate the digestive process, it is, as is known, advantageous to remove as rapidly as possible the peptones already formed from the solution.

The dialyser does this when one keeps the fluid bathing it free from peptones. To render this as convenient as possible a Mariotte's flask, *c*, whose bottom contains three holes, is placed on the glass; one hole near the centre, the other two near the periphery. Through one of the marginal holes a glass tube, *a*, 5 Ctm. wide, is passed water-tight, so that it projects 2 Ctm. into the funnel between the glass wall and the parchment filter. In the tube is a moveable tapered glass rod which acts as a valve. The pointed end of the valve projects below beyond the tube, so that it is supported by the wall of the funnel as soon as the flask is placed on the diffusion-glass. An ascending tube, *b*, fills the second marginal hole and ends in an obliquely ground opening 2 Ctm. below the bottom of the flask.

Fig. 2.



When the flask is filled with fluid and placed upon the diffusion-funnel in such a way that the ascending tube remains as a valve outside the filter, then the contents run into the funnel and glass, until the opening of the ascending tube is closed by the level of the fluid.

The fluid is then hindered from escaping by the valve-tube, through the pressure of the outer air, which cannot equalise with that contained in the flask, until the level is caused to fall, and permit bubbles of air to rise through the ascending tube. Thus the level of the fluid under the margin of the filter is kept constant at the series of holes; through these holes the interchange of fluids outside and inside the funnel in the glass is favoured. During the diffusion a vigorous circulation takes place, in that the fluid within the funnel, because of the absorbed peptones, is heavier than that outside, and passes away by the lower opening of the funnel and permits more dilute solution to enter by the series of holes. If it is desired to renew completely the fluid outside the filter, one only requires to empty the diffusate through the outflow tube *f*. It is filled with dilute HCl from the Mariotte's flask-system. A thermometer which projects into the Mariotte's flask permits of the temperature in the digestion-chamber being regulated.

The method of obtaining pure albuminous bodies by dialysis as practised specially by Alexander Schmidt and his scholars, made it desirable to change the water outside the dialyser very often. For this purpose our apparatus is easily arranged. One has only to see that the used supply of water in the Mariotte's flask can at every time be renewed. Remove the thermometer, cork up the hole in the bottom of the flask, and place a funnel tightly into the neck of the same, and close air-tight the tube of the funnel from above by a glass rod covered with a piece of caoutchouc.

If the flask is empty and the level of the water somewhat fallen in the diffusion-glass, raise the glass rod which acts as a stopper and filter the former through the funnel in a few seconds. One has to take care that the funnel for filling is closed, before the fluid in the diffusion-funnel has risen so near to the margin of the filter, that it is likely to pass over into the already diffused material.

ON A LARGE ORGANISED CYST IN THE SUB-DURAL SPACE. By J. C. Ewart, M.B., *late Junior Demonstrator of Anatomy in the University of Edinburgh, and now Curator of the Museum, University College, London.*

On removing the skull-cap of a male subject in the dissecting-room of the University of Edinburgh, the dura mater of the left side was seen to vary greatly in colour. The inner portion from half an inch to an inch and a half in breadth, bounded by the superior longitudinal sinus internally, and by a wavy line externally, was of a pale and somewhat milky appearance. The outer portion, extending from the wavy line as far as the cut margin of the bone, was dark brown, mottled with green. On reflecting the dura mater towards the right side it was found to be quite normal in appearance, and the dark colour to be due to a large cyst occupying the sub-dural space extending along the whole length of the left cerebral hemisphere. By raising the upper border of this cyst it was found to vary from a quarter of an inch in its transverse diameter at the edges, to an inch and a quarter in the centre, and the outer surface of the hemisphere on which it was lying to be so compressed as to be concave antero-posteriorly and from above downwards, and slightly displaced towards the right side. There were no adhesions between the wall of the cyst and the membranes under it, nor was there any appearance of disease of the part of the cerebrum which had been thus compressed, but the dura mater adhered slightly to the outer surface of the cyst and required to be separated from it by the handle of the scalpel.

The cyst nearly occupied the whole length of the left side of the cranial cavity, but did not extend into the base. A thin vascular membrane extended from the margin as far as the superior longitudinal sinus above and to the crista galli and over the greater part of the tentorium cerebelli below. After removal it was found to be oval in shape, about the size of a kidney, measuring seven and a half inches anteroposteriorly, two and a half inches transversely at the broadest part, and varying in thickness from four lines at the margin to an inch and a quarter in the centre. The surface lying on the left hemisphere was paler but more vascular than the one in contact with the dura mater. The vessels radiated from a central plexus towards the vascular membrane already mentioned, and passing through it were connected with those of the dura mater. The walls were firm and fibrous, and measured from two to three lines in thickness except at the margins, where they were from four to six lines. The sac contained a dark brown fluid in which were numerous soft fibrinous masses resembling softened and broken down blood-clots. Adhering to the inside of the sac was a thick fibrinous layer, firm externally, but soft and friable towards the centre.

On microscopic examination the fluid contents were found to be chiefly composed of blood-corpuscles lying amongst a large quantity of granular matter. The red corpuscles were shrunk and very irregular, and many of them seemed as if in the act of breaking down into granules similar to those around them. The soft masses were chiefly composed of fine fibrous bands forming a network, in the spaces of which were blood-corpuscles and blood-crystals. Numerous groups of blood-crystals were seen amongst the granular matter and between the layers of connective tissue forming the wall of the cyst, thus accounting for its dark colour. The soft layer lining the sac only differed from the fluid contents in containing more fibrinous matter and having scattered through it or aggregated together numerous white blood-corpuscles, resembling in section a lymphatic gland or a mass of adenoid tissue.

The proper wall of the sac was composed of fibrous tissue in different stages of development. The inner layers were most vascular. Outside the vessels were numerous white blood-corpuscles, also spindle and branched cells apparently derived from these corpuscles, some of which were arranged in rows as if to form capillary blood-vessels. External to this layer fine fibres were lying amongst the cells, increasing in number as they approached the outer surface, where well-marked bundles of connective tissue with numerous nuclei around them, probably the nuclei of their cellular sheaths, were visible. On teasing the most external layers of the sac a number of fine elastic fibres were found between and around the bundles of connective tissue, some of them connected with nuclei, thus supporting the view that elastic fibres are developed from the processes of branched cells. The smallest vessels lying in the inner layers of the wall of the sac were larger than ordinary capillaries, and had very thin walls; those in the outer layers were small and less numerous, owing to the compression produced by the shrinking of the newly formed fibrous tissue.

The vessels on the surface of the hemisphere lying under the cyst were empty and contracted, those between its margin and the middle line were distended and engorged with blood. On removing the membranes a small portion of the cerebral substance about half-way up the ascending frontal convolution was found softened. This softening only extended about a quarter of an inch into the substance. On slicing the brain no clots or softened parts were found, but the left lateral and third ventricles seemed to project a little beyond the middle line towards the right side.

I obtained the following history from the physician who had charge of the case:—

J. H., æt. 64, bargeman, was admitted into hospital for the treatment of a large abscess on the internal aspect of the left thigh. The abscess was opened and in three weeks after admission was nearly healed, and the general condition of the patient much improved, when he suddenly became insensible and comatose, as if suffering from compression of the brain, in which state he remained for nearly three days. On the evening of the third day he died, but for a short time before death he regained his consciousness. There was no exciting cause for this attack, which came on suddenly while he was lying quietly in bed. The patient had often been in hospital before, suffering from cold and general debility, the effects of exposure and intemperance, but there was no history of any special disease, nor of any previous attacks in any way resembling the one above described which so rapidly proved fatal. The only abnormal condition noticed by the physician was indistinctness of speech with a tendency to "mouth" his words. From this history and the post-mortem appearances it seems evident that death resulted from the pressure produced by the cyst lying on the left cerebral hemisphere. But as the walls of the cyst were composed of well-developed fibrous tissue it is also clear that it must have existed for some time previous to the attack. The conclusion then is that at some period—months or years—before the fatal attack a thin membrane was formed, which increased gradually at first, but three days before death, by a sudden extravasation of blood into its substance, caused compression of the brain. This membrane may either have originated from blood extravasated into the sub-dural space or from lymph effused, the result of inflammatory changes not uncommon in the cerebral membranes of drinkers. It may in the first place have originated from exuded lymph which afterwards was organized into connective tissue, the outer layers of which being most developed would by their shrinking compress and strengthen the superficial vessels, while those in the centre with thin dilatable walls lying amongst the soft organizing cells would be liable to distension and rupture when the blood pressure was increased. In this way small quantities of blood would be extravasated into the membrane from the inner vessels, separating the firmer layers of tissue on the surface from each other, and forming them into the walls of the sac. As the extravasations increased the sac would gradually become larger, and at the same time the walls would also increase in thickness through the migrating *leucocytes* finding their way towards the periphery, and mingling with the already formed spindle-cells gradually get converted into connective tissue. While the sac continued to increase in this gradual manner there would be no sudden compression of the brain, and hence there were no marked symptoms nor any change except perhaps slight difficulty in articulating words. This might have been due to the pressure on the left frontal convolution, or to the want of teeth in the upper jaw. That considerable displacement of the brain if done gradually is possible without producing any symptoms is well known—the brain having time to accommodate itself to the circumstances; whereas, when there is sudden compression, the symptoms are very decided and unmistakeable. In this case, when three days before death the patient became insensible and comatose, a larger amount of blood than usual must have suddenly been poured into the cyst, leading to sudden compression, the effects of which only for a short time disappeared when the brain had so far recovered from the shock as again to carry on to some extent its wonted functions.

If instead of being the result of inflammation the cyst originated from blood extravasated from one of the meningeal arteries, the formation of the walls would be almost identical with that described above, and with what takes place in an antiseptic blood-clot. In a blood-clot there is nothing living and active but the white blood-corpuscles; it is thus a very low form of tissue, and under ordinary circumstances very easily breaks down, but when treated antiseptically, as Prof. Lister's cases prove, instead of breaking down, the *leucocytes*, though comparatively few in number, have not only sufficient vitality to prevent the breaking down of the clot, but tend gradually to become developed into connective tissue, which as it shrinks aids in drawing the edges of the wound together. The red corpuscles partly escape in the discharge and partly are absorbed, leaving in their place crystals of blood-pigment. Besides the protection afforded by the antiseptic dressing, a thin layer of young epithelial cells is after some time found covering the exposed part of the clot. What here takes place under the naked eye we may conceive to take place in a clot lying on the surface of the brain. In this case the cranial bones with their coverings, together with the dura mater, take the place of the antiseptic dressing, and if there are no unfavourable conditions present in the system of the patient, the white blood-corpuscles are developed into a membrane, firm at the surface, but soft in the centre. The outer firm layer, like the epithelium over a blood-clot, becomes an extra source of protection for the less active red blood-corpuscles and fibrin within. In this case, as before, the occasional rupture of the inner vessels would lead to the gradual increase of the cyst.

Taking the previous history and post-mortem appearances into consideration, we must conclude that a cyst had occupied the sub-dural space without producing any apparent symptom till three days before death, when by its sudden increase in bulk the brain was so compressed that it was unable to perform its usual functions. How this cyst originated it is difficult to say. It may have been from extravasated blood, or from inflammatory changes of the dura mater leading to exudation of lymph which was afterwards organized into connective tissue.

THE DECOMPOSITION OF UREA. By JAMES REOCH, M.A., M.B. *Newcastle-upon-Tyne.*

IN the *Lancet* for Oct. 17, 1874, I described some experiments on the alkaline fermentation of urine, which went to prove that urine gradually decomposes from the moment of emission until it reaches the point of alkalinity in about 10 days or more. From further experiments, however, I am inclined to believe that these results are true only of the height of summer, that being the time when the former experiments were made. From about 100 urines which I have followed towards and beyond alkalinity, I shall adduce evidence to shew that the urea is changed into carbonate of ammonia by the action of a fungus whose germs are contained in the atmosphere. This fungus is developed much more quickly by heat, and therefore in summer it commences its growth at once and completes it speedily, while in winter it takes a much longer time to gather sufficient strength to begin its work. The following is an example of a winter urine kept in a tall glass jar.

1st day	+ 16·3	48th day		+ 3·5	69th day	− 160·3
8th „	+ 18·0	55th „		− 12·3	76th „	− 437·5
27th „	+ 11·7	58th „	top	− 9·4	83rd „	− 452·5
34th „	+ 17·7		bottom	− 22·6	90th „	− 397·1
41st „	+ 5·0	62nd „		− 19·8	97th „	− 350·0

My method of experimenting was to use small pieces of litmus paper, which were stirred round in the urine by a glass rod. I had two standard solutions, one of sulphuric acid, and the other of soda purified by alcohol. A weighed quantity of soda was dissolved in a litre of water so as to make a standard solution of about 7—10 mgms. per cc., and the H_2SO_4 was diluted to correspond, or rather to be somewhat stronger, say about twice this strength. I invariably operated on 10 cc. of urine, and if 2 cc. of soda of strength 10 mgms. to 1 cc. were required to neutralize the tint of the litmus paper, I put it down as + 20, but if 1 cc. of H_2SO_4 of strength = 20 mgms. soda in 1 cc. was required, I still expressed it as soda, but with a minus sign, thus − 20. All positives therefore are to be understood as acid urines, and all negatives as alkaline, and the numbers are the expressions of acidity or alkalinity in mgms. of soda per 10 cc. I may also mention that I call the day when urine is voided, the first day, although only an hour or two may elapse before it is examined.

The following urine was kept in a tumbler during the winter.

1st day	+ 15·9	49th day top	– 19·8	65th day	– 129·2
4th „	+ 19·1	bottom	– 19·8	72nd „	– 180·8
23rd „	+ 22·9	51st „ top	– 21·3	79th „	– 281·0
30th „	+ 22·6	bottom	– 19·4	86th „	– 190·4
37th „	+ 3·9	54th „ top	– 33·8	93rd „	– 93·1
44th „	– 6·6	bottom	– 30·2	100th „	– 46·8
		59th „	– 59·4	107th „	– 27·5

The general results of my experiments are expressed in the above instances, where in a tall urine-glass holding 6oz. and exposing 1 sq. in. of surface alkalinity is reached in about 15 days in summer, but in winter in not less than 50 days, while in a tumbler urine may become alkaline in 10 days in summer and in less than 40 in winter. I believe these results are due to the different amount of surface exposed to the development of the germs of the fungi, but would merely observe here, that the form of vessel must always be taken into account in experimenting on the fermentation of urine; for I shall give an example of a urine kept in an uncovered basin, to shew the absolute impossibility of obtaining accurate results without the most minute attention to the conditions of the experiment.

1st day	+ 15·9	34th day	– 348·3
6th „	+ 4·6	41st „	– 119·9
13th „	+ 4·2	48th „	– 60·2
20th „	– 16·5	55th „	– 77·4
29th „	– 60·1		

Now on comparing these three typical cases it will be observed that in a basin urine quickly turns alkaline, and as quickly the alkalinity increases and then diminishes, doubtless from the fact that not only does it offer a large surface for the development of the fungus spores, but also a large surface to carry away the CO_2 and NH_3 which are produced, while in a tall glass the urine remains long acid and then still longer alkaline; in fact, I have urines which are still considerably alkaline though kept without cover for nearly two years in these tall glasses.

It will also have been observed that the amount of alkalinity is by no means always the same at the top and bottom of a urine decomposing in a tall glass or in a tumbler. From some urines examined last autumn, I give the following as examples.

		Top.	Bottom.
I.	48th day	– 43·9	– 57·7
II.	47th „	– 11·1	– 28·3
III.	43rd „	– 107·7	– 107·2
IV.	42nd „	– 191·5	– 250·8
V.	41st „	– 84·4	– 123·2
VI.	40th „	– 187·0	– 220·9
VII.	38th „	– 70·0	– 64·6
VIII.	37th „	– 144·3	– 242·4
IX.	36th „	– 141·2	– 168·4
X.	35th „	– 115·9	– 163·2

A long and slender pipette or burette is passed down to the bottom of the urine and a sufficient quantity drawn up, which may be examined either as it is, or after filtration.

The first 6 of these cases are from tall glasses, and the last 4 from tumblers, basins being obviously unsuitable for such experiments; but I think they shew conclusively that in the great majority of cases decomposition goes on much more actively at the bottom than at the top of a normal urine. Of course carbonate of ammonia is a volatile salt, and would tend to lose both its CO_2 and its NH_3 at the surface, and would therefore in solution become naturally stronger at the bottom than at the top, supposing it was originally of the same strength throughout; but this is insufficient to explain the great amount of the discrepancy, for direct experiments shew that the diffusive power of carbonate of ammonia is very slight: thus a lump weighing 6·167 grms. being placed in a tumbler and 200 cc. H_2O added, it was found next day that nearly all had dissolved; but even on the third day the difference between top and bottom was considerable; while after being stirred round on that day it presented only slight differences from day to day between the top and bottom.

	Top.	Bottom.		Top.	Bottom.
2nd day	– 34·9	– 560·0	7th day	– 124·4	– 133·9
3rd ,,	– 35·8	– 400·6	14th ,,	– 88·6	– 96·4
stirred total	– 149·9		21st ,,	– 30·7	– 30·3
4th ,,	– 141·4	– 143·3	28th ,,	– 5·1	
5th ,,	– 140·5	– 144·2			

I shall attempt to shew afterwards that the true reason of this is that the fungus spores are somewhat heavier than water, especially when thoroughly wet, and they tend therefore to sink to the bottom and continue their work there, though originally coming from the atmosphere. But it must now be asked, what reason there is for supposing it to be a fungus at all which causes the decomposition? and to this I would first answer, that the cause, whatever it is, cannot be a liquid body or a body in solution, for if a putrid urine be filtered and the filtrate added to fresh urine no effect follows more than if so much distilled water had been added, but if the precipitate be added to fresh urine decomposition quickly follows. And here must be noted the superior advantage of conducting these experiments in cold weather, for at that time the urine normally requiring 40—50 days for decomposition, it is easily seen that if it turns alkaline in 24 hours a powerful ferment has been added, while if no change follows for more than a month it may be safely said that the reagent used has no effect whatever. Now I have several times added filtrate from putrid urine to fresh urine without any effect, and I have allowed the filtrate to stand some time before adding it, and yet obtained no result. If there be any exception to this rule it arises from imperfect filtration. In the following case, for example, a tall jar containing urine more than a year old was inverted, all that would flow out of it was received in a filter and some fresh urine was divided into two parts, 4½ oz. being put into the dirty jar, and 4½ oz. into a clean jar to which 3 cc. of the filtrate from the putrid urine were added.

	Dirty Jar.	Clean Jar.
1st day	+ 18·9	+ 18·9
6th „	0·0	+ 18·4
25th „	– 67·7	+ 14·5
32nd „	– 127·8	+ 17·7
39th „	– 231·4	– 1·4
46th „	– 220·5	– 4·7
53rd „	– 314·9	– 50·9
57th „	– 341·4	– 84·8
60th „	– 358·3	– 133·9
67th „	– 337·7	– 287·6
74th „	out	– 360·1

Again, 4 cc. of the filtrate after standing for 34 days were added to 9 oz. of urine in a basin with the following result:

1st day	+ 15·9	26th day	– 46·8
5th „	+ 14·1	33rd „	– 268·7
12th „	+ 13·0	40th „	– 93·3
18th „	acid	47th „	– 43·3
19th „	– 14·1	54th „	– 52·2
22nd „	– 21·7		

In this latter case the urine simply followed its usual course in the basin, and it would therefore appear that the filtrate from putrid urine not only does not cause decomposition itself, but cannot undergo that change upon standing which would cause it to act as a ferment when afterwards introduced into urine. But the same thing is proved in another way. If urine be allowed to stand in a tumbler it will gradually decompose, and a fungus similar to ordinary mould will form upon its surface, while a precipitate is formed upon the bottom, consisting largely of earthy phosphates, but containing also fungus spores [1], amorphous masses, and particles undergoing molecular or Brunonian movements. It is a very simple matter to divide the urine roughly then into the scum at the top, the fluid body, and the grumous precipitate; and if these three be added separately to quantities of fresh urine it will be found that the middle or body of the urine has very little effect; and I don't believe that it would have any if it were possible to prevent some of the precipitate from mixing with it when poured out. Thus, a urine four months old having been taken, the fungus at the top was washed in a gallon or two of water, and added to one urine, 6 oz. of the middle part to another, and 6 drms. of the pp. to a third.

[1] These spores are smaller than those on the surface perhaps from the action of the salts of the urine contracting them by osmosis.

A. 20¼ oz. fresh urine +scum.			B. 25 oz. + 6 oz. putrid.			C. 18½ oz. + 6 drms. putrid pp.		
Day			Day			Day		
1.		+ 11·6	1.		+ 6·7	1.		+ 6·7
2.	Top	+ 6·7	2.	Top	– 6·3	2.	Top	– 28·3
	Bottom	+ 2·8		Bottom	– 6·3		Bottom	– 42·4
6.	Top	– 12·1	6.	Top	– 33·9	6.	Top	– 99·9
	Bottom	– 114·1		Bottom	– 37·7		Bottom	– 278·1
7.	Top	– 22·6	7.	Top	– 47·1	7.	Top	– 117·9
	Bottom	– 120·7		Bottom	– 81·1		Bottom	– 308·4
16.	Top	– 233·8	17.	Top	– 188·6	16.	Top	– 296·2
	Bottom	– 369·6		Bottom	– 224·4		Bottom	– 398·7

From this experiment as well as from many others I conclude that the precipitate from putrid urine is the most efficacious ferment to fresh urine, and next to that the fungus and scum from the top, while the middle, though constituting the great bulk of the urine, comes far behind; and this very fact seems to shew that vibriones are not the cause of this fermentation, for they exist most largely in the body of putrid urine and on the surface, while it is the precipitate at the bottom which acts most speedily. I believe that the cause of this is that on the surface the fungus spores are matted together by the development of much mycelium, while at the bottom they are more numerous and much more free, and therefore able to act on a larger scale. If urine be examined microscopically, it will be found that these fungus spores invariably appear after a few days, and are much more numerous at the bottom than at the top of the urine, because they sink readily, but gradually they shrink up to a much smaller size. Before proceeding more directly to this fungus, two causes of the alkaline fermentation must be discussed, as they are the only two which have been urged with force, the bacteria theory being merely hypothetical. The first of these attributes the decomposition to mucus, but in reply to this I would remark, from more than 50 cases, that however carefully urine may be filtered, it invariably undergoes the alkaline fermentation at the usual period, and that if the same urine be partly filtered and partly not there will be no difference in the time of decomposition, or if there is, it is as likely to be the other way as not. The other theory attributes the decomposition to nitrogenous material fermenting. This expression is extremely vague, and is met by the assertion that this material has by no means the power which is ascribed to it, for I have added the most putrid nitrogenous material to fresh urine, and always found it required nearly a week to turn it alkaline, whereas the ferment from putrid urine itself invariably acted in less than 24 hours; and moreover, it was as likely as not that the nitrogenous material contained some spores similar to those which I believe are the real cause of the alkalinity of urine. To return to the fungus. If the mould from the top of putrid urine be well washed, it will be found to present little else than fungus spores when examined microscopically, but these are matted together, partly by mycelium which entangles earthy phosphates, and partly by a homogeneous material. When this mould is sown in fresh urine it becomes an active ferment. The following example is interesting for several reasons.

20 oz. Urine + washed Mould.

Day.	Top.	Bottom.	Day.	Top.	Bottom.	Day.	Top.	Bottom.
1.	+ acid	acid	10.	– 17·9	– 149·0	20.	– 215·0	– 320·6
2.	acid	acid	11.	– 37·7	– 151·8	22.	– 215·0	– 320·5
3.	+ 6·7	– 92·4	13.	– 44·3	– 163·1	29.	– 247·0	– 325·2
4.	+ 6·7	– 86·6	15.	– 86·7	– 156·5	36.	– 191·0	– 233·6
5.	+ 2·8	– 105·6	16.	– 142·4	– 166·9	43.	– 160·1	
6.	+ 2·5	– 126·3	17.	– 197·0	– 264·9	50.	– 108·3	
8.	– 7·5	– 137·6	18.	– 177·2	– 319·6	57.	– 63·9	
9.	– 11·3	– 153·7	19.	– 209·3	– 344·1	62.	– 46·4	

In this case nothing could be clearer than that the cause of the decomposition lay in the mould, although the latter had been well washed, for the decomposition began at the bottom, and went on for several days before the upper part of the urine lost its acidity. But another curious fact must be noticed: the alkalinity remained nearly stationary at the bottom after the first week. Suspecting that the cause of this was due to the earthy phosphates precipitating themselves on the top of the mould and preventing its action, I stirred the urine vigorously on the evening of the 15th day, and next day there was of course a large increase of alkalinity at the top, but it developed itself at the bottom each day thereafter in quite a remarkable degree. Were this a solitary case nothing could be inferred from it, but having several times obtained these results, and never any contradictory, I infer that the atmospheric oxygen is not necessary for the alkaline fermentation of urine outside the body any more than inside the bladder, for I have often found urine becoming alkaline at the bottom when certain ferments were added, while still acid at the top; and moreover this action requires contact between the ferment and the urea in the solution, for how otherwise can the cessation of the process be explained when the fungus is covered up by the earthy phosphates? and the same fact which shews that the fungus cannot act through the phosphates shews also that the latter have no part in the fermentation, which conclusion is confirmed by direct experiment. It is quite possible that there may be subordinate causes for the alkaline fermentation, but it appears to me that they are chiefly of use in determining the greater or less rapidity of growth of the fungus, which is the real agent. Thus soda, potash and ammonia have no influence whatever unless added in quantity sufficient to make the urine alkaline, and even then they act more by affording a nidus to the fungus than by their own power; for true decomposition, as indicated by a great increase of alkalinity, does not occur much before the usual time, but when it has begun it goes on faster, especially if ammonia or its salts be used. The following from a basin to which soda was added and a jar in which carbonate of ammonia was placed may serve as examples of these facts.

Basin 17 oz. urine. + 1·040 grms. Na HO	
2nd day	– 2·03
7th „	– 3·8
9th „	– 26·0
15th „	– 58·8
20th „	– 102·7
25th „	– 155·6
30th „	– 179·1
44th „	– 44·3
58th „	– 43·8

Jar 12 oz. urine. + 1·680 grms. Amm. Carb.	
6th day	– 4·7
8th „	– 4·7
16th „	– 30·1
27th „	– 190·4
30th „	– 239·5
41st „	– 116·1
48th „	– 62·3
69th „	– 19·6

There appears to be a considerable difference between the action of H_2S and $(NH_4)_2S$, principally I believe owing to the large quantity of alkali in the latter; and this illustrates very well a point which is often forgotten, that a fœtid smell has no connection with the alkaline fermentation in the sense of cause and effect. Some imagine that putrid matter of any kind, provided it be very fœtid, will set up fermentation, but I have several times added flesh that had been rotting in water for more than a year, and yet the urine remained acid for a week afterwards. Since the ferment from putrid urine invariably acts in less than 24 hours, it is evident that the ferment from other nitrogenous putrid matter is feeble by comparison, and probably depends on some fungus spores being present. It appears that H_2S instead of hastening delays the decomposition considerably, probably owing to its acid nature and its poisonous influence on low forms of animal and vegetable life.

15½ oz. urine had H_2S passed in all night.

	Top.	Bottom.
4th day	+ 12·7	+ 13·8
11th „	+ 7·8	+ 7·8
18th „	+ 9·2	+ 9·5
25th „	+ 5·7	+ 5·3
32nd „	+ 2·8	+ 3·5
39th „	+ 2·5	+ 2·8
46th „	– 14·0	– 14·0
53rd „	23·2	– 23·2

21¾ oz. urine + ℥j. Amm. Sulphide.

	Top.	Bottom.
5th day	– 46·6	– 48·9
12th „	– 33·6	– 34·1
19th „	– 83·1	– 195·0
26th „	– 227·5	– 415·7
33rd „	– 250·8	– 415·5
40th „	– 225·4	– 374·6
44th „	– 206·2	– 348·9

These two examples shew the difference which I have found to exist between these two putrid substances, depending, as I think, on the large quantity of alkali in the latter. According to my experiments phosphate of lime has little effect on the alkaline fermentation beyond probably that of forming a nidus like ammonia in which the real ferment may develop itself more quickly. Glucose has no effect whatever, nor has yeast, either the ordinary fluid kind, or that which is known as German yeast—for I have added them all to urine—and yet the urines did not become alkaline in less than three weeks or a month.

I have also mixed a large quantity of gamboge with urine because its particles very readily undergo Brunonian movements: if therefore the alkaline fermentation was caused by a molecular movement among the particles of urea this might possibly hasten it, but the result was negative, as indeed might be expected from the fact that H_2S did not quicken decomposition, although the particles of sulphur which it deposits undergo these movements very distinctly.

After having thoroughly satisfied myself by numerous experiments that the solids of putrid urine, either as precipitate or as scum on top, were the real cause of alkaline decomposition, I strove to separate this fungus as much as possible from extraneous matter, and then sowing it in urine and in solutions of pure urea observe the result. Some urea being thoroughly dried, weighed, and then dissolved in water so as to make a 2 per cent. solution, was titrated with a solution of nitrate of mercury, $\begin{matrix} 171 \text{ mgms.} + \;\; 9{\cdot}3 \text{ cc. } H_2O \\ 205 \quad\quad - \; + 10{\cdot}3 \text{ cc. } H_2O \end{matrix}$ required $\begin{matrix} 17{\cdot}15 \\ 20{\cdot}9 \end{matrix}$ nitrate solution. The urea being thus shewn to be sufficiently pure the following experiments were performed. Into 8 bottles some weighed urea was put and enough water added, to make a 2 per cent. solution, then into the first three a weighed quantity of dried fungus was put, into no. 4 6 drops of ordinary yeast, into no. 5 12 drops of yeast, and into the rest the residue of a putrid urine which had dried in the air after the most of the liquid had been poured off, though in the last bottle the putrid residue was somewhat liquid. The following table gives these experiments.

1.	225 mgms. urea	+ 11·25 cc. H_2O	+ 32 mgms. dried fungus	94·4 per cent.
2.	450 " "	+ 22·5 "	+ 32 " " "	49·1 " "
3.	347 " "	+ 17·35 "	+ 23 " " "	less than 50 " "
4.	256 " "	+ 12·8 "	+ 6 drops yeast	0 " "
5.	333 " "	+ 16·75 "	+ 12 " "	0 " "
6.	309 " "	+ 15·45 "	+ one or two grains of putrid matter	106·8 " "
7.	240 " "	+ 12· "	+ do.	103·9 " "
8.	356·5 " "	+ 17·825 "	+ do.	above 100 " "
9.	282·5 " "	+ 14·125 "	+ do.	104·6 " "
10.	335 " "	+ 16·75 "	+ 12 drops putrid precipitate	107·7 per cent.

Now since urea = $CN_2H_4O = 60$ it is evident that if urea becomes carbonate of ammonia by assuming two molecules of water, $CN_2H_4O + 2\,H_2O = (NH_4)_2CO_3$, it is evident that as much dilute sulphuric acid will be required for neutralization as if every 60 parts of urea contained 17×2 of ammonia; but it is much easier to equate the sulphuric acid with soda NaHO $=$ NH_3HO and NaHO $= 40$; it follows that if all the urea be decomposed into carbonate of ammonia and nothing else, 60 parts of urea will equal 80 of soda, and therefore every milligram of urea when decomposed will require as much H_2SO_4 solution as corresponds to $1\frac{1}{3}$ mgm. of soda. Bearing this in mind we can understand the results in the last column of the above experiments, where the dried fungus, acting for 13 days, effected a variable amount of decomposition of the urea: the yeast had no effect, and in no. 4, where 256 mgms. urea were used, 23 cc. nitrate of mercury solution gave no yellow with solution of carbonate of soda, 25 cc. gave a transient yellow, and 25·6 the ordinary yellow indicating excess of the nitrate. In the last 5 cases the decomposition was complete, and even more H_2SO_4 was used than theory required, because of the

1.	100 mgms. urea	+ 5 cc. H_2O	+ 32½ mgms. fungus req.	1·35 sulph. acid,	
2.	99 ,, ,,	+ 5·05	+ 30 ,, ,,	11·85 ,, ,,	,, and gave 24 mgms. dried pp.
3.	87 ,, ,,	+ 4·4	+ 37 ,, ,,	10·7 ,, ,,	,, ,, ,, 24 ,, ,,
4.	87 ,, ,,	+ 4·4	+ 45 ,, ,,	8·1 ,, ,,	,, ,, ,, 22 ,, ,,
5.	102 ,, ,,	+ 5·1	+ 36 ,, ,,	12·6 ,, ,,	,, ,, ,, 17 ,, ,,
6.	63 ,, ,,	+ 3·15	+ 7 ,, ,,	8·05 ,, ,,	,, ,, ,, 8·5 ,, ,,
7.	101 ,, ,,	+ 5·05	+ 73 ,, ,,	12·3 ,, ,,	,, ,, ,, 21 ,, ,,
8.	141 ,, ,,	+ 7·05	+ 29 ,, ,,	17·0 ,, ,,	,, ,, ,, 18 ,, ,,

alkalinity of the putrid precipitate, which however could not have increased the result by more than 5—10 per cent., because only a small quantity was added. These results indicating that the urea is completely decomposed into an ammoniacal salt, it was desirable to inquire whether the fungus increased in weight; for it is evident that some of the carbon might possibly be fixed in the process, and thus carbonate of ammonia might not be the only result. As the fungus did not appear to stand drying very well, I pressed it between folds of blotting paper, and estimated, by drying two specimens in the water-bath, that they contained from 40—46 per cent. of solid matter. The solutions after standing for 12 days behind a stove were titrated with sulphuric acid, and a drop of tincture of litmus, and then the fungus was received on a weighed filter and dried in the water-bath.

Now each cc. of sulph. acid corresponds to $11\frac{1}{4}$ mgms. of soda, and calculating the fungus which was added at 40 per cent. of its weight, we read the above table thus:

1.	100 mgms. urea	= 133·3 mgms. soda,	but	15·2 found
2.	99 „ „	= 132 „	„	123·1 „
3.	87 „ „	= 116 „	„	120·2 „
4.	87 „ „	= 116 „	„	90·8 „
5.	102 „ „	= 136 „	„	141·5 „
6.	63 „ „	= 84 „	„	90·2 „
7.	101 „ „	= 134·7 „	„	138·2 „
8.	141 „ „	= 188 „	„	190·8 „

In the majority of these cases the urea was completely decomposed, the slight excess of alkali obtained being due to the alkalinity of the fungus, as I shall afterwards explain, but in the first two there was less decomposition because the fungi, after being weighed, had been dried to a considerable extent in the water-bath before immersion. The results of the experiment as regards increased weight of the fungi were less complete, owing mainly to the hypothetical deduction I was compelled to make from not being able to dry them completely before use.

2.	30 mgms. fungus calc. at 40 per cent.	= 12 mgs.,	but obtained	24 mgm
3.	37 „ „ „	= 14·8 „	„	24 „
4.	45 „ „ „	= 18 „	„	22 „
5.	36 „ „ „	= 14·4 „	„	17 „
6.	7 „ „ „	= 2.8 „	„	8·5 „
7.	73 „ „ „	= 29·2 „	„	21 „
8.	29 „ „ „	= 11·6 „	„	18 „

The great majority of these shew an increase of small extent, but still a perceptible increase; yet as one shewed a considerable decrease which could not possibly have taken place, it was plain that the method was defective, and as one of those fungi which I had dried in the water-bath had acted pretty well, I made four experiments with fungi thoroughly dried before use.

1.	12 mgms. fungus +	10	cc. of soln. urea (2 per cent.)	
2.	14 ,, ,,	10	,, ,, ,,	
3.	10 ,, ,,	10	,, ,, ,,	
4.	18 ,, ,,	10·1	,, ,, ,,	

These were left behind the stove for twelve days and then examined, but each of them proved a complete failure, a drop or two of sulphuric acid being sufficient to acidify the litmus. It was evident therefore that though the fungi might act after being put into the water-bath, yet when kept there for three or four hours till thoroughly dry their efficacy is destroyed. The only method open therefore was to repeat my former experiments, drying the fungus as carefully as possible between folds of blotting-paper until it appeared as thoroughly dry as this plan could leave it. The following experiments therefore were performed.

10 cc. sol. urea	+ 34½ mgms. fungus req.	12·15 cc. H_2SO_4,	and gave	21 mgms. fungus
10 ,, ,, ,,	+ 46 ,, ,, ,,	12·1 ,, ,,		23 ,, ,,
10 ,, ,, ,,	+ 44 ,, ,, ,,	12·6 ,, ,,		32 ,, ,,
10 ,, ,, ,,	+ 41 ,, ,, ,,	11·25 ,, ,,		26 ,, ,,
10 ,, ,, ,,	+ 29 ,, ,, ,,	12·1 ,, ,,		17 ,, ,,
10 ,, ,, ,,	+ 38 ,, ,, ,,	12·3 ,, ,,		26 ,, ,,
10 ,, ,, ,,	+ 36 ,, ,, ,,	11·6 ,, ,,		21 ,, ,,
10¼ ,, ,,	+ 15 ,, ,, ,,	10·5 ,, ,,		11 ,, ,,

These results were obtained after the bottles had been left behind the stove for seven days: as each cc. of the sulph. acid solution was equal to 22·1 mgms. soda, 10 cc. of a 2 per cent. solution of urea ought to have required 12·1 cc. H_2SO_4, which was very nearly what they all required, but in nos. 7 and 8 a rather less amount was needed, because there was not room enough behind the stove to arrange all the bottles in line, they therefore stood a little further off than the others; and this is what I have always found, that the fungus was the more active the greater the heat to which it was exposed, unless the heat was near the boiling point. When 58 and 69 mgms. of the fungus such as was used in the above experiments were dried in the water-bath they became 31 and 35 respectively, and after long drying lost rather more than 1 mgm. between them. We may therefore consider 58 + 69 becomes 31 + 35 − 1, that is 100 mgms. of fungus became 51 mgms. when dried. Calculating the undried fungi therefore at 51 per cent. the above table becomes

1.	34½ mgms. fungus	= 17·6 dried, but obtained	21,	increase 3·4
2.	46 ,, ,,	= 23·5 ,, ,,	23	0·0
3.	44 ,, ,,	= 22·4 ,, ,,	32	9·6
4.	41 ,, ,,	= 20·9 ,, ,,	26	5·1
5.	29 ,, ,,	= 14·8 ,, ,,	17	2·2
6.	38 ,, ,,	= 19·4 ,, ,,	26	6·6
7.	36 ,, ,,	= 18·4 ,, ,,	21	2·6
8.	15 ,, ,,	= 7·7 ,, ,,	11	3·3

The great majority of these cases shew an increase, but as it was impossible to free the filter from the sulphate of ammonia without washing so freely as to carry away some part of the precipitate which might have been soluble, the point must still remain doubtful; but it is perfectly evident that the increase of the fungus, if it takes place at all, is only trifling, and utterly out of proportion to the quantity of urea which it causes to become carbonate of ammonia.

We must now inquire into the chemistry of urea itself, to see if it will help us in explaining its decomposition by the fungus. The formula of urea is CN_2H_4O, and it is isomeric with cyanate of ammonia, but its rational formula is still unknown. Some have regarded it as identical with carbamide, but this is quite uncertain. I wish, however, particularly to insist upon the fact that it is quite different from cyanate of ammonia, and does not behave like an ammoniacal salt at all, because though no one asserts that it does, yet many chemists seem to imagine that its decomposition into carbonate of ammonia is a very simple matter. They say a molecule of urea simply assumes two molecules of water and becomes carbonate of ammonia, and if you ask for an explanation of the process, you are informed it is diastatic or catalytic; but this explanation is merely verbal. I shall give two reasons why urea is not to be regarded as a salt of ammonia, because I shall have to refer to them afterwards. First, it gives no precipitate in the cold with Nessler's reagent, whereas ammonia and all its ordinary salts give a dense pp. Secondly, it gives no murexide coloration with a mixture of alloxan and alloxantin, whereas all the ordinary salts of ammonia do so. If, therefore, powerful chemical reagents which can act on ammonia in presence of such a comparatively strong acid as phosphoric acid will not reveal the presence of ammonia in urea, how can its decomposition be regarded as a simple matter?

The fact is, solution of urea will remain unaltered for an indefinite period. I have boiled it and evaporated it to dryness in the water-bath, and yet it gave no trace of ammonia whatever. It is commonly said that heating it with alkalies in solution changes it into CO_2 and NH_3, but if by this is meant that it is caused to assume H_2O and become carbonate of ammonia, it is an entire mistake. I have repeated the following experiment several times: 5 cc. of a standard solution of caustic soda were evaporated in the water-bath with some urea and the residue dissolved in 5 cc. H_2O; no ammonia was recognizable by Nessler's test if it had been thoroughly dried, and the solution was found to be not caustic soda but carbonate of soda. The following therefore is the true reaction, since the action of KHO is the same: $CN_2H_4O + 2KHO = K_2CO_3 + 2NH_3$. This however does not take place when ammonia is used instead of KHO or NaHO. I have already said that the formation of murexide is a very delicate test for distinguishing carbonate of ammonia from urea, and when I evaporate some urea with liq. ammon. fort. in the water-bath I get urea only, and no trace of carbonate of ammonia. It is evident therefore that the formation of the latter salt by the fungus cannot be explained by supposing a slight formation of NH_3, that taking CO_2 from urea and water, and liberating as much NH_3 to go on in continuous action. Inasmuch however as KHO or NaHO when boiled with solution of urea gives rise to ammonia and carbonate of the alkali, it is evident that CO_2 and NH_3 are potentially though not actually present in urea. And here I may observe that Nessler's reagent does not give such a large precipitate as might be expected, for the carbonates exert a peculiar action upon it. If four test-tubes be taken and solution of the carbonates and bicarbonates of soda and potash poured into them, and then the same quantity of very dilute ammonia added to each, it will be found that with the bicarbonates no pp. at all is obtained by Nessler's reagent, even on boiling; with carbonate of soda it does not come down till it is boiled, and though it comes down in the cold with carbonate of KHO, yet it does not seem to act so thoroughly as in the case of distilled water.

Another supposition which might be put forward by some to explain the decomposition of urea by the fungus, is that the latter being composed of spores which consist of a cell-wall and very fluid contents, there might be a continual endosmose and exosmose, in the course of which the urea was changed. We know that osmosis has been explained by a hydration and dehydration of the membrane of the septum, and it might therefore happen that in the course of such an action the urea was united with water. To test this I put some solution of urea in two experiments into a piece of bladder, whose outside was placed in distilled water. After remaining 24 hours each side gave a copious pp. with nitrate of Hg, indicating that urea had passed copiously through; but no trace of NH_3 was observed in either. I conclude, therefore, that this will not explain matters. It appears to me, however, that there is one very simple and satisfactory explanation of the decomposition, if only it be the true one. I suppose that the fungus develops ozone or nascent oxygen, and that in urea CN_2H_4O the CO is picked out, the C fixed by the fungus, and the O given off. What would happen? $CN_2H_4O + O + 2H_2O = (NH_4)_2CO_3 + O$. In other words, the oxygen forms CO_2 and the amidogen seizes H_2 from water, liberating O to go on as before. Thus with a minute point of C fixed by the fungus there would be given off a minute portion of oxygen sufficient theoretically to decompose any amount of urea. Practically of course a larger quantity would be required than what would suffice in theory, just as in the sulphuric acid and etherification processes the theoretical quantity of reagent acting continuously is always exceeded. But this theory must have a better foundation than mere plausibility, and I have therefore made many experiments to ascertain if ozone is given off in any part of the process of decomposition. Thus six bottles being taken, 5 cc. of a 2 per cent. solution of urea and some fungus were put into each, along with 2 drops of starch solution and $\frac{1}{2}$ cc. up to 2 cc. of a solution of KI, consisting of 879 mgms. to 10 cc. H_2O. No result appeared for two days, but it is well known that iodide of starch is soluble in alkalies, and therefore Fresenius recommends the addition of dilute H_2SO_4. Accordingly, to the second bottle I added $\frac{1}{4}$ cc. of H_2SO_4 of a strength 1 cc. = 22·1 mgms. soda, without any result; to the third, $\frac{1}{2}$ cc. with immediate production of iodide of starch, which dissolved again in a short time; to the fourth, $\frac{3}{4}$ cc., and to the fifth, 1 cc., with production of intense blue. Two days afterwards the blue had disappeared from the fourth bottle and had nearly gone from the fifth, but on adding 2 cc. H_2SO_4 to each of these bottles the colour came out well, as also in the third bottle; but when nos. 1 and 6 had H_2SO_4 added to them there was no result whatever. Nor could I afterwards obtain any result from them at all. These results are anomalous, but as far as they go they tend to shew the production of ozone or nascent oxygen. The fungus may act on the starch as well as the urea, and the reactions of iodide of starch to complex organic bodies are by no means thoroughly understood. Thus sulphurous acid destroys it entirely, and alcohol greatly; and as it is impossible to know what becomes of it in the course of the decomposition of urea, seeing that carbonate of ammonia is produced in which the iodide is abundantly soluble, it appears to me that a few positive examples in which it has been found outweigh others in which it has not been found. I have performed other experiments, but though I obtained the blue in some cases, in others I was unsuccessful. My experiments when there was no urea with the fungus, but only water, starch and KI, were all unsuccessful, for in none of these cases was the blue iodide of starch produced even on adding dilute H_2SO_4. We may, therefore, infer that in the decomposition of urea it is not the water which is first decomposed by the fungus, but the urea itself.

I made some observations to find if this process of decomposition in the urine itself was attended with any increase or absorption of heat, but with a result which as yet is negative. The comparative thermometry of the urine is by no means easy. The temperature of the air is always changing, and the urine following that change exhibits the temperature not of the air as it is at any moment, but that which it had an hour or two before, the specific heat of a mass of fluid being very considerable. The quantity of urine therefore, as well as the vessels containing it, must be exactly similar, and the most minute precautions be attended to, for I have found the temperature of the top and bottom of the same urine at the same time to differ by more than 1°C. After observing a healthy and a decomposing urine for a week the vessels are cleaned out and a fresh healthy urine put into the vessel which formerly held the decomposing urine, and vice versa. To get rid of any difficulty from the thermometers being unequal they should be reversed from day to day. After some experiments conducted with the above precautions, I think it beyond doubt that the difference in temperature between a healthy and a putrefying urine does not amount to $\frac{1}{4}$th of 1°C. Whether there is any difference at all I believe can scarcely be made out by the ordinary thermometer, but at any rate it is very slight. As to the constitution of the fungus itself it is very difficult to pass an opinion, from the difficulty of obtaining it free from extraneous matter. A large surface is required to develop a large quantity, but the liability to contamination with dirt is much increased. In the urine the triple phosphate clings to it with remarkable tenacity; its crystals become imbedded in the masses of mycelia and spores, so that however long the fungus is washed it retains them in considerable quantity. After drying the fungus in the water-bath they appear as white spots upon it, and if the fungus be burnt with soda-lime in a combustion tube they make it appear to contain a considerable quantity of nitrogen; but that the fungus itself contains no nitrogen is evident, because while liq. potass. evolves ammonia from it, however often it has previously been boiled in water, yet if boiled in very dilute HCL no ammonia is obtained on subsequent boiling with liq. potass., and yet the spores appear unchanged when examined microscopically after treatment with dilute HCL. Further, that the NH_3 is wholly due to the triple phos. and not to urate of NH_3 is proved, in that evaporation with HNO_3 and further treatment with KHO gives no trace of murexide. They consist, therefore, of carbon united with hydrogen and oxygen, but how far they are allied to other species of moulds is a very difficult question in the present imperfect state of our knowledge on the whole subject. I have sown the green mould scraped from an old pair of boots in urine. It lay at the bottom for some days and then the urine decomposed from below upwards.

	Top.	Bottom.
21st day	+ 7·0	− 416·2
28th „	− 134·0	− 604·4
33rd „	− 465·2	− 571·3
39th „	− 558·7	− 575·9

In this case the urine was "urina sanguinis," and therefore very acid and loaded with urea; perhaps this may account for the delay in commencing action, but it certainly appears as if the mould were the cause when the alkalinity was so great at the bottom while it was still acid at the top. In another case I sowed the mould scraped from the leather thong of a whip and from the surface of the dried excrements of a cat. In this case many of the spores were different from the usual shape, and decomposition was extremely rapid.

	Top.	Bottom.
5th day	+ acid	− 175·7
10th „	− 47·5	− 306·1
12th „	− 86·2	− 285·7
16th „	− 265·2	− 331·5

In other cases I have sown mould from carrots and baskets, &c., but I have not in all cases obtained the same results. It appears to me that in many cases the white mould is composed almost entirely of mycelium and the green almost wholly of spores. Now the mycelium never seems to act in decomposing urine, and therefore the spores alone ought to be added. Further, it is just possible that there may be great difficulties in the growth of the fungus in the acid urine, as I have invariably found that the progress towards alkalinity was very much slower than the progress afterwards in the full development of the alkalinity already established. If the acidity of urine be regarded as 1, its full alkalinity when all the urea is decomposed is considerably above 20, but it seldom takes more than twice or thrice the time in undergoing this last process that it took to undergo the first. In all cases, however, the decomposition is progressive, and they greatly err who imagine that all at once the urea begins to turn into an ammoniacal salt, and that the whole of it turns all at once like a precipitate forming on the addition of a reagent. Not only is the decomposition always progressive, but even in the most favourable cases in a vessel it takes about a week to effect it thoroughly. I don't speak of cases where the urine is continually subject to agitation and consequent renewal of fresh particles exposed to the decomposing influence, but of cases where the urine is left at rest in a jar. When a large quantity of the grumous precipitate from putrid urine is added to fresh urine, it always turns alkaline in less than 24 hours, but the urea is never completely decomposed under a week, as the following case, among many others, will clearly shew:

16 oz. urine + 11 drms. putrid pp.

	Top.	Bottom.
2nd day	− 39·6	− 108·4
4th ,,	− 73·5	− 312·1
7th ,,	− 154·6	− 389·4
13th ,,	− 241·3	− 448·8
16th ,,	− 283·9	− 461·9
23rd ,,	− 263·4	− 441·5
30th ,,	− 261·7	− 370·7
37th ,,	− 256·5	− 340·8
44th ,,	− 178·0	− 280·9
51st ,,	− 170·2	− 227·6

In this case though there was a much larger quantity of alkali developed by the second day than the urine originally had of acid, yet the alkali increased pretty fast for some time, and then more slowly, as if it formed at first when in small quantity a stimulus to its own development, but when more largely developed a hindrance. I have already mentioned the influence which the form of the vessel in which the urine is placed has upon the development of ammonia, and I may here give an example of the length of time in which it will remain in a vessel of the decanter shape with a pasteboard cover simply to protect it from dust.

	Top.	Bottom.
1st day	+ 13	+ 13
5th ,,	− 10·4	− 10·4
10th ,,	− 64·1	− 92·4
15th ,,	− 148·0	− 243·2
18th ,,	− 216·8	− 260·2
26th ,,	− 294·1	− 292·2
57th ,,	− 209·0	
78th ,,	− 154·7	
84th ,,	− 136·6	

In this case some putrid urine was added. I have not given all the figures, for it was examined more than thirty times; but between the 18th and 57th days both top and bottom gave 200 and odd mgms. of alkali without a single exception, shewing no variation to speak of for fully 40 days. The important question of how urea is decomposed within the body I must leave untouched, because I have made no experiments on the subject, but if the facts which I have described throw some insight into the probable nature of those processes which go on in the paralyzed bladder, they will not have been without some service.

NOTES ON THE PRESENCE OF TWO PRECAVAL VEINS IN A DOG.

By Magnus R. Simpson, *Student of Medicine, University of Edinburgh.*

In the dog, as in the human subject, the blood from the head, neck, and pectoral limbs is normally returned to the right auricle of the heart by a single precaval vein, formed by the junction of the right and left innominate veins.

In man, as is well known, owing to the persistence of the left duct of Cuvier of the embryo, two superior, or precaval, veins are occasionally met with. A few months ago, whilst dissecting a young puppy, which had been drowned, so that the veins were all gorged with blood, I found, on raising the sternum, and removing the thymus gland, two distinct precaval veins, each formed by the junction of the jugular and subclavian veins of its own side, so that there was no left innominate. The right vena cava ran its natural course by the side of the innominate artery to open into the right auricle, being joined shortly before doing so by the vena azygos major. The left vena cava lay at first over and almost parallel to the thoracic portion of the left subclavian artery, then gradually crossing it, passed backwards over the root of the left lung, and reached the dorsal surface of the heart, where it opened into the coronary sinus, which was of considerable size. A small vertebral vein opened into it close to its origin, and nearer the heart it was joined by a small superior intercostal vein. In this specimen, as in the abnormal disposition of the great veins occasionally occurring in man, the presence of a left precaval vein was due to the persistence of the left duct of Cuvier.

NOTICES OF BOOKS.

Leçons sur la Physiologie et l'Anatomie Comparée. By H. MILNE EDWARDS. Vol. X. 2nd part, and Vol. XI. 1st part. Paris, 1874.

PROFESSOR Milne Edwards has published, during the past year, two additional parts of his great work on Comparative Anatomy and Physiology. In the 2nd part of his 10th volume he describes the locomotory apparatus, and in the 1st part of the 11th volume he treats of locomotion, and commences the description of the nervous system.

Lehrbuch der Vergleichenden Embryologie der Wirbelthiere. By Dr S. L. SCHENK. Vienna, 1874.

PROFESSOR Schenk's treatise on the Comparative Embryology of the Vertebrata, though extending to no more than 198 octavo pages, gives a clear and interesting account of the series of complicated changes, which, taking place in the fertilized vertebrate ovum, result in the production of various forms of vertebrate structure. The book is not a mere compilation, but embodies a considerable amount of original work. More especially may we notice the numerous excellent woodcuts, which have a softness not usually met with in illustrated German works on Anatomy, and large numbers of which are for the first time published. We can recommend the work as a most useful compendium of the subject.

An Introduction to Human Anatomy, including the Anatomy of the Tissues. Part I. By WM. TURNER, M.B., Professor of Anatomy in the University of Edinburgh. Edinburgh, 1875.

As stated in the Preface this Introduction to Human Anatomy was prepared as the article "Anatomy" for the ninth edition of the Encyclopædia Britannica. It has no pretence to be an exhaustive treatise, and the object the author had in view, when writing, was to give an exposition of the principles on which the human body is constructed, rather than to put before the reader a detailed description of the several organs. Part I. contains an account of the Organs of Locomotion, of the Simple Tissues, of the Nervous System, and of the Organs of Sense. It is illustrated by 114 woodcuts, most of which are original.

Studien über die Verknöcherung und die Knochen des Schädels. By Dr A. J. VROLIK. Haarlem and Leipzig, 1873.

THE third part of the *Niederländisches Archiv für Zoologie*, June, 1873, edited by Prof. Selenka of Leiden, consists of a series of papers by Dr A. J. Vrolik on the bones of the skull. In the first of these papers the author discusses the names which have been given to the bones of the skull in the osseous fishes by different authors, and compiles a useful table of synonyms. In the second and third papers he describes the skull in several Physostoma and Gadidæ, with especial reference to the pro-otic, epiotic and opisthotic elements of Huxley, and concludes that these are not to be regarded as integral parts of the cranium. In the last paper he describes the ossification of the temporal bone in man and several other mammals. He finds four points of ossification in the human petrous bone and two in the mastoid part, but in no other mammal has he seen the same number. He considers that it is not yet proved that in mammalia generally the number of ossific centres in the petro-mastoid cartilage is constant, and that consequently it cannot definitely be said whether they have, or have not, a constant type of arrangement. We join with Prof. Selenka in an expression of regret at the early death of this promising young anatomist.

The Mind of Man. By ALFRED SMEE, F.R.S. 8vo. George Bell and Sons, London. 1875.

THIS is a natural system of Mental Philosophy, comprising, as stated in the preface, either in detail or in principles, nearly everything which the author has ever written on the subject. It traces the ideas from simple impressions derived through the senses, and goes on to the elucidation of the more complex mental phenomena, including the subjects of religious thought, faith, mental fallacies, the voltaic mechanism of the nervous system, and concludes with the relation of man to the universe and the Author of all things.

Unsere Körperform und das physiologische Problem ihrer Enstehung. Von WILHELM HIS. 8vo. F. C. W. Vogel, Leipzig, 1875.

THIS is in the form of a letter to a naturalist friend. It gives a general, rather than a detailed, account of embryology, comprising the views of the author, and enters into the bearing of the subject upon the great questions of evolution, heridity, adaptation, &c. It is, as might be expected from the reputation of the author, an able and interesting treatise.

REPORT ON THE PROGRESS OF ANATOMY[1].

By Prof. TURNER and D. J. CUNNINGHAM, M.B., C.M.

OSSEOUS SYSTEM.—Henry E. Clark notes (*Glasgow Med. Journ.* July, 1874) a case of CERVICAL RIBS. On the right side were 12 ribs, 11 dorsal, and one cervical which was narrow and round. On the left side 12 dorsal ribs with a rudimentary rib attached to the last cervical vertebra.——R. Hensel makes some comparative observations on the OSSA INTERPARIETALIA of the human skull (*Reichert u. du Bois Reymond's Archiv*, 1874, No. v.).——A. Heuberger, a pupil of Kölliker's, writes an inaugural dissertation on the NORMAL ABSORPTION AND INTERSTITIAL GROWTH OF OSSEOUS TISSUE (*Würzburg Verhandl.* 1874). His observations are made with especial reference to the arrangement and use of the osteoklast cells described by Kölliker (*Reports*, May and November, 1872 and May, 1874), and to the antagonistic observations of Strelzoff. Heuberger confirms Kölliker's views.——Julius Wolff (*Virchow's Archiv*, LXI. 417) also discusses the GROWTH OF BONE with reference to the observations of Kölliker and the other anatomists who have recently written on this subject. ——Z. J. Strelzoff replies in *Archiv für Mikrosk. Anat.* Nov. 1874, to Kölliker's criticism on his *Observations on the growth of bone.*—— Ranvier (*Arch. de Phys.* Janvier, Fevrier, 1875) contributes a short paper upon PREPARATIONS OF OSSEOUS TISSUE WITH ANILINE BLUE INSOLUBLE IN WATER AND SOLUBLE IN ALCOHOL. He first describes the method he has adopted in preparing the bone. A portion of the diaphysis of a long bone is removed from the body and *immediately* immersed in water. In this it is allowed to lie for a year or more, and during this time the water of maceration must be frequently changed. It is important that it should at once be placed in the water, because if it be allowed to remain exposed to the air for a short time the moisture of the osseous tissue will evaporate and its place will then be taken by the grease contained in the medullary canal and large Haversian canals. When this grease gets access into the canals and substance of the bone, it is impossible to get rid of it. After the maceration is completed, sections are made with a saw, and then ground down and polished to a proper fineness. During the polishing, a thick paste is formed by the dust of the bone mixed with particles separated from the stone. This paste is applied to the surface of the section and penetrates the canaliculi for a short distance, and to get rid of it the section must be scraped with a scalpel on both surfaces. The section thus prepared is placed in an alcoholic solution of aniline blue concentrated by heat. It is left in this for two hours, and then it is thoroughly dried by evaporation in a vapour-bath.

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

The section is then ground upon its two surfaces upon a hone moistened by a 2 p. c. solution of chloride of sodium, washed in the solution, and mounted as a permanent preparation in a mixture of glycerine and a solution of salt in equal parts. In addition to the ordinary appearances presented by transverse sections of bone, these preparations demonstrate three facts which are not recognizable in the usual preparations of osseous tissue. First, amongst the corpuscles comprised in the Haversian systems some are represented by a simple chink the breadth of which does not much exceed that of a primitive canaliculus. To these thin corpuscles Ranvier has given the name of "*Confluents lacunaires*" of bone, and he considers that they represent corpuscles in the process of atrophy. The second fact relates to the most peripheral canaliculi of a Haversian system. These proceed on towards the circumference of the system in a straight line, and appear as if they were on their way to anastomose with canaliculi in neighbouring Haversian systems or intermediary systems; but on reaching the limit of the system to which they belong, they bend back upon themselves, and after a short course anastomose with canaliculi belonging to their own system. Ranvier has called these canaliculi "*canalicules récurrents,*" and he states that they form a very elegant border to the circumference of the Haversian system. The third fact relates to the distribution of the corpuscles and canaliculi in the islands of osseous tissue which lie between the Haversian systems. In these islands may be observed circles the diameter of which is very variable, and which correspond to the fibres of Sharpey cut transversely.——Wenzel Gruber publishes (*Mém. de l'Acad. Imp. de St Petersb.*, Jan., 1875) a monograph on SESAMOID BONES preformed in hyaline cartilage in the tendon of origin of the gastrocnemius. He concludes that a true sesamoid bone in man only forms in the outer head of this muscle, but in many mammals in both heads.

MUSCULAR SYSTEM.—E. Weber (*Arch. de Phys.*, July and Sept., 1874, 489) contributes an article upon THE NUCLEI OF STRIATED MUSCLE IN THE ADULT FROG. He begins by referring to the views held by Kölliker and Schultze upon the nature of these bodies. The former, he states, considers that they are nuclear in character because he failed to discover any limiting membrane corresponding to a cell-wall—the space in which they lie being simply bounded by the fibrillæ. From this therefore he concludes that Kölliker still looks upon a cell as necessarily consisting of cell-wall, contents, nucleus and nucleolus. Schultze, on the other hand, maintains that the muscular corpuscle is a cell, inasmuch as it consists of a nucleus surrounded by a granular mass of protoplasm– this latter being most evident at the two extremities of the nucleus owing to the pressure exercised on the surface of the cell. Weber then gives the results of his own investigations, first as regards the shape of the nucleus, and second as regards the existence of the protoplasmic surrounding. The nuclei, he states, are flat, ovular when seen from the front, and rod-shaped when seen in profile. They contain in their interior one or perhaps more nucleoli, and their contents are homogeneous or slightly granular. Such is the form they present when treated by alcohol, picrocarminate, and then acetic acid; but in certain cases, especially when the muscular fibrillæ are caused to swell up rapidly by the action of strong acetic acid, they have the form of rectangular plates of a greater or less size. On one of their borders he has often observed a line or stria which is found to consist in a projection of the margin—a crease advancing towards the eye of the observer, and analogous to the "crêtes d'impreinte" of Ranvier in the flat cells of tendon. Other nuclei present like striæ on their two sides, and the author asserts that he has been able to satisfy himself that these creases exist as a normal condition. In transverse sections the nuclei are seen to have a rod-shape, and they are arranged irregularly in the interior of the circle which represents the cut muscular bundle. Moreover one of the extremities of the rod is often bent back upon itself—this corresponding to the crease. Some of these nuclei are triangular in form with concave sides as if they had been compressed between three cylindrical bundles, for being of a soft consistence they are naturally moulded into various shapes by the interstices between the fibrillæ in which they lie. Lastly, the author affirms that in none of the numerous investigations, which he has made with the view of discovering the true form of the nucleus, has he ever been able to recognize the existence of protoplasm surrounding the nucleus. The nuclei were always sharply defined, ovular, and more or less elongated. Sometimes they were lodged in a fusiform crevice of which they only occupied the central part. In this case however the rest of the crevice was always homogeneous, and shewed nothing like protoplasm.——Ranvier (*Arch. de Phys.*, Nov., Dec., 1874, 774) writes upon THE SPECTROSCOPIC PROPERTIES OF STRIATED MUSCLES. This article, he tells us, is supplementary to a note upon the same subject which he communicated to the French Academy of Science. He gives in detail the method by which the spectrum is obtained, and explains that this property of muscle depends upon the transverse striæ of the muscular fibres—these acting on the light in the same way as a series of parallel lines traced upon glass. With the muscular spectrum, he states, we are able to recognize in blood the spectroscopic characters of the hæmoglobin, and he has constructed an instrument for this purpose. The muscles of organic life, and also, curiously enough, the striated muscular fibre of the heart, are not endowed with this property. Lastly, he gives the application of the spectrum of muscle to the physiology and pathology of muscular tissue.——W. Gruber describes (*Reichert u. du Bois Reymond's Archiv*, 1874, 467) a case in which a MUSCULUS PLANTARIS BICAUDATUS ended by its supernumerary tendon in the ligamentum popliteum.——E. Von Teutleben gives a description (*Archiv für Naturgeschichte*, 1874, 78) of the muscles and mechanism of MASTICATION in the vertebrata.

BLOOD-VASCULAR SYSTEM. Ranvier (*Arch. de Phys.*, July and Sept., 1874) writes upon the DEVELOPMENT AND GROWTH OF BLOOD-

VESSELS. He first points out that the phenomena of development and growth are two distinct processes, which must not be confounded the one with the other. He then traces the development of blood-vessels in the rabbit. He states that at the great curvature of the stomach the vascular network is close and compact, but as the vessels extend into the membrane the meshes widen and open out, and near these, in all transparent parts, circular or elongated opalescent spots may be distinguished. Some of these are almost microscopic in size but others have a diameter varying from a half to two or three millimetres. To these spots he has given the name of "*taches laiteuses*," or *milky spots*. It is in the middle of these spots that the first elements of the vessels appear. They are of two kinds, viz., vascular and non-vascular. The latter possess an endothelial covering upon each surface with bundles of connective tissue and cells of various kinds in their interior. The endothelium is very irregular, and this he believes to be due to its frequent penetration by lymphatic cells (see Abstract of his paper upon the formation of the apertures on the great omentum). *The bundles of connective tissue* in the "taches laiteuses" do not belong to them alone, but are simply fibres pursuing their course and thus crossing through the spots. *The cells* are of three kinds, (1) lymphatic cells, (2) connective-tissue cells, (3) vaso-formative cells. The first are similar in all respects to the lymphatic cells which exist free in the peritoneal cavity, and they exhibit amœboid movements. Some, smaller than others, and possessing in their interior granules very susceptible to picrocarminate and hæmatoxylon, occupy the centre of the spots, and shew very lively movements under favourable conditions. When the spots are large, however, they are seen in groups, and become slightly angular from the pressure of the one against the other. The connective-tissue cells are not endowed with amœboid activity, and they differ from the cells of the stroma in other parts of the membrane only in having more numerous ramifications. They are generally laid flat upon the connective-tissue bundles and surrounded by lymphatic cells. *The vaso-formative cells* are the first rudiments of the blood-vessels, and they differ from the other cells mentioned. They do not exist in the adult rabbit, but are found in rabbits varying in age from 15 days to 6 weeks. They are irregularly branching, finely granular bodies, varying much in size and in the number of their prolongations. The branches frequently anastomose so as to form a network which covers the entire extent of a non-vascular "tache laiteuse," and presents the appearance of a vascular network. The author states that he has not determined the number of vaso-formative cells which enter into the formation of such a network, but he considers that it is not great, and that a single cell can by itself form a network. These cells are not gifted with amœboid activity. By fine injections of Prussian blue and gelatine and other means, Ranvier states that he has been able to satisfy himself that the vaso-formative networks in the non-vascular "taches laiteuses" are quite distinct from the vascular networks. In preparations coloured by carmine after the action of Müller's fluid, the body of the vaso-formative network appears to be formed by cylindrical anastomosing branches. In the midst of the granular protoplasm, which forms the mass of all the branches, elongated rod-shaped nuclei are disposed in the line of the long axis of the branch which they occupy. These nuclei are often larger at one end than the other, and sometimes they shew signs of approaching division, or perhaps two are seen lying close to each other—the sign that one has already divided. Ranvier affirms that it is easy to shew that these vaso-formative networks ultimately develope into capillary networks. In certain cases a vascular branch may be seen to penetrate a non-vascular "tache laiteuse," and place itself in relation with a network of which the half or three-fourths is permeable to injection. He states that he is not in a position to assert with confidence the origin of the vaso-formative cells, but that it is his impression that they are derived from the connective-tissue cells. Lastly, the author points out the mode of growth of vessels, and shews that this is accomplished by cellular buds or offshoots which, at first impervious, are hollowed out one after the other so as to receive the blood. The expansion of the vascular system, he states, may take place either by the growth of old vessels or by the independent formation of capillary networks, which by degrees come into relation with the general circulation. ——Julius Arnold gives (*Virchow's Archiv*, LXII. 157) the first part of a memoir on the RELATION OF THE BLOOD AND LYMPH-VESSELS TO THE JUICE CANALS. His observations are in harmony with those of Carter, published in this *Journal*, IV. p. 97, and previously communicated to the Royal Society of London, 1864.——C. Giacomini writes an elaborate memoir (Turin, 1874), illustrated with five plates, on HIGH DIVISION OF THE BRACHIAL ARTERY.——H. Frey describes (*Reichert u. du Bois Reymond's Archiv*, 1874, 633) the NERVES SUPPLYING THE BLOOD-VESSELS OF THE UPPER LIMB. The rule appears to be that the venous and arterial trunks of the limb receive nerves from the nervous trunk immediately contiguous to them.——Duret (*Arch. de Phys.* July, Sept. and Nov., Dec., 1874) writes upon THE ANATOMY OF THE ENCEPHALIC BLOOD-VESSELS, and traces the relations which cerebral hæmorrhages and softenings have to the distribution of these vessels. At the end of each article he places the results of his investigations before us in a tabular form. Reference may also be made to the first article of the series which appeared in the January number of the same Journal; and in our last *Report* was given an abstract of another paper by him on the same subject, also published in the *Archives*.——G. Gulliver records (*Proc. Zool. Soc.*, Nov. 3, 1874) measurements of the RED BLOOD-CORPUSCLES. In *Hippopotamus amphibius* the average diameter is $\frac{1}{3429}$th inch: in *Otaria jubata* $\frac{1}{3000}$th inch: in *Trichecus rosmarus* $\frac{1}{2760}$th inch.

CONNECTIVE TISSUE.—Le Goff and Ramonat (*Journ. de l'Anat. et de la Phys.* Jan. et Fev. 1874) contribute a memoir upon THE CELLULAR ELEMENTS OF TENDON. After a brief résumé of the different views that have been advanced on these cells, they describe very fully the various methods they have adopted in preparing tendon for microscopic investigation, and then they give the results of their own researches. They state that embryonic tendon is formed by nuclei placed closely together, of which the long axis corresponds to that of the tendon. At this stage they are separated merely by a small amount of amorphous material, but later on each is surrounded by a slender cellular body, which is most marked at the two extremities, so as to give it the appearnce of a fusiform cell. In the same preparation both nuclei and fusiform cells may be observed, but at a more advanced stage only rows of fusiform cells can be recognized. The extremities of these cells are in some cases drawn out considerably so as to form long prolongations. The authors believe that certain of these cells enter into the formation of the fibres of tendon and disappear, whilst others are shut up in the intervals which are formed between the primitive bundles of these fibres. These fusiform cells, which are thus enclosed, are arranged in parallel rows, and in the course of their development they present very diverse appearances. Similar rows of cells may also be met with in adult tendons, as in those of the eye of the sheep, &c. Here the cells are arranged in several layers which cross each other as they follow the arrangement of the primary bundles. Moreover, on changing the focus, other rows may be observed, having a perpendicular or oblique direction to the first. They describe a different arrangement in the guinea-pig and mouse. Here also the cells are fusiform and in parallel rows, but some are observed to be in the process of segmentation or already segmented, forming others which are themselves beginning to divide. Again, certain of the cells may shew a constriction borne alike by the cell and the nucleus, or perhaps the nucleus is divided into two or three, whilst the surrounding protoplasm is entire or shews only a constriction. It is thus that the cells of tendon multiply, and in such numbers that in one preparation the authors state they have seen as many as twenty cells placed end to end, with the ends of the row terminating in spindle-shaped extremities. In the young guinea-pig long rows of quadrangular cells, arranged end to end, may be seen. These are slightly flattened by the pressure exercised on them by those which are above and below, and they present a nucleus in their centre. In the mole the cells, also placed end to end, are spherical with a large nucleus, and frequently they are enclosed in a sheath of amorphous matter. Again, this sheath may be observed to be dimpled with cavities, in each of which is placed a cell which does not fill it completely. They state that the last phase in the evolution of the tendinous cells is to be found in the filiform tendons of the rat and mouse. Here on each side of the cell very distinct processes may be observed. They believe that these processes are produced by the cells being compressed by those above and below them. The cells cannot therefore develope in their long axis, and thus they are forced to send processes into the spaces between the primary fasciculi. They state that nucleoli are generally present in the cells of tendon. When one is present it is central, but when there are two they are excentric, and one is larger than the other. In none of their preparations have they ever seen the cells applied upon the bundles, although this is an appearance described by many histologists. In this memoir the authors also give the results of some investigations, which they have made, into the structure of the sesamoid nodule of the tendo Achillis. In horizontal sections they state that numerous cells, varying in appearance according to their age, are observed lying in large spaces circumscribed by partitions of laminated tissue. In the tadpole only, large nuclei, some of which are already converted into veritable cells, are to be found, and the laminated tissue which surrounds them is analogous to the embryonic tendinous tissue. Following this same nodule in its evolution the nuclei are observed to become surrounded by protoplasm, which increases rapidly. Fibroplastic bodies are developed, and these give birth to the fibres, which, compressed and united in groups, take in the adult nodule the appearance of large partitions circumscribing roomy spaces which are occupied by masses of cells. These cells are mostly spherical, or rather lenticular, but their form is evidently subordinate to that of the mesh in which they lie. Some by reciprocal pressure come to resemble pavement epithelial cells, and all are not uniform in size, as side by side may be seen a small cell and one three or four times larger. Some of the cells may even resemble the fusiform cells of tendon, but they are considerably larger, and others may be prismatic with a nucleus near their large extremity. They state that it is by no means rare to find two nuclei in one cell, thus presenting an analogy with the cells of tendon. The nucleus is generally in the centre of the cell, and may contain one or two nucleoli. The nucleus, however, is sometimes seen near the wall, and it may even cause the wall to protrude in a hernial fashion. The cells are surrounded by an amorphous material, which often forms for them a complete and isolated bed. Lastly, they point to the great analogy which exists between this nodule and tendon, and more especially when we compare it with the tendons of the mole. In both we have large cells with nucleus and nucleolus embedded in an amorphous material. Moreover, a study of the development and the manner in which reagents act on these two structures bears out this analogy.——G. Thin gives an abstract (*Proc. Roy. Soc. London*, Jan. 21, 1875) of his observations on THE CONNECTIVE TISSUES, more especially in connection with the presence of flat and quadrangular cells in the cornea, in addition to the stellate cornea corpuscles; the presence of large flat cells on the surface of tendon; of smaller quadrangular cells investing the secondary and tertiary bundles of a tendon in double layers, and of long, narrow, flat cells covering the primary bundles; of the presence of a double layer of quadrangular and hexagonal cells in the perimysium and neurilemma; of the existence of branched cells in the neurilemma; of flat, ribbon-shaped bands in the fibrillary tissue of the neurilemma, and of extremely fine but sharply contoured fibrillæ in the fibrillary tissue of skin and tendons. The author infers, from appearances presented by the rods of the retina after prolonged maceration in aqueous humour, that the rods and cones are composed of fibrillary tissue in its simplest form.——W. Waldeyer makes, in *Archiv fur Mikrosk. Anat.* Nov. 1874, some observations on the CELLS OF THE CONNECTIVE TISSUE. He discusses the characters of the so-named flat cells of the fibrillary connective tissue of the cornea corpuscles, and of large round cells rich in protoplasm, which belong to the connective tissue, such as the cells of the interstitial substance of the testicle, the cells of the coccygeal and intercarotid bodies, large round cells not unfrequently found as an adventitious investment of the cerebral vessels, the cells of the supra-renal bodies, of the corpus luteum, and the serotina cells of the placenta.

SYNOVIAL MEMBRANES.—J. G. van der Sluÿs writes his inaugural dissertation on the *Structure of the Synovial Membranes*, Leiden, 1875. He comments on the recent observations of Hüter, Reyher and Tillmanns, relates his own researches, and sums up the results of his investigations as follows:—1. The synovial membrane consists of connective tissue which is, on its free surface, very rich in cells. 2. These cells belong to the group of round connective-tissue-cells distinguished by Waldeyer. 3. The hollows in which they lie are most probably lymphatic spaces. 4. The capillaries of the synovial membrane never lie uncovered (naked) on the surface. 5. The markings of Hüter are artificial products which take place from the action of nitrate of silver upon the synovial fluid.

GREAT OMENTUM.—Ranvier (*Arch. de Phys.*, July and Sept., 1874) writes an interesting paper upon THE FORMATION OF THE MESHES OF THE GREAT OMENTUM. He begins by disputing the view, advanced by Rollett, that these meshes are surrounded by a bundle of fibrous tissue arranged in the form of a ring. He asserts that they are formed simply by the separation of bundles of connective tissue the one from the other. The meshes are thus each bounded by two, three, or a greater number of bundles, which continue their course and go to concur in the limitation of other meshes. The boundaries of the meshes are clothed by a layer of endothelium continuous upon the two surfaces of the membrane. The author states that the relation of the endothelium to the completely-formed holes is both varied and peculiar, but three principal types may be recognized:—(1) a black line marks the circumference of the aperture, and at this line the cells terminate both on the superior and inferior surface; (2) there is no such line, and a cell clothing the border of the hole belongs partly to the superior and partly to the inferior surface of the membrane; (3) an aperture is surrounded by a continuous excentric line, limited by an endothelial cell; upon the other surface of the membrane several lines diverge from the hole, and these are the limits of several cells. This disposition of the endothelial cells has led the author to adopt the following theory upon the formation of the apertures. The lymphatic cells, which exist free in great numbers in the cavity of the peritoneum, have the power of piercing and passing through the membrane in a manner similar to that in which a blood-corpuscle passes through the vascular wall. One of these lymphatic cells fixes itself between two of the endothelial cells, separates them, and then places itself in relation to the deep surface of an endothelium-cell on the opposite surface of the membrane.

It pursues its course, perforates this cell, and finally disengaging itself becomes free once more. It will leave behind it, however, an opening bounded on the side by two cells of the endothelial investment, and on the other by a single cell presenting in its centre a loss of substance or aperture. The author also shews how the same hypothesis applies to the first arrangement of endothelial cells indicated. The piercing lymphatic cell having set out from an endothelial interline gains the opposite side at the point of separation of several cells of that surface. Ranvier affirms that his theory is likewise supported by a study of the distribution of the holes, and by the observation of the holes in the process of formation. The apertures are mostly found at a distance from the vessels, where the membrane is thin, and where there is little provision for the nutrition of the part. In addition the distribution is quite irregular, and from this may be inferred that the membrane plays a passive part in the phenomenon which converts it into a network. Lastly, he states that in the process of formation some of the holes contain a globular cell, similar in form and size to a lymphatic cell, and separated from the circumference by an unequal black border, which is formed by the fixation of the nitrate of silver by the albumen. In some places also a lymphatic cell may be observed fastened between two endothelial cells; but all cells found in this position have not the characters of lymph-cells, as many are small, and have an analogy to endothelial cells.

MUCOUS MEMBRANES.—M. Debove (*Arch. de Phys.*, Jan. 1874) shews the existence of a SUB-EPITHELIAL ENDOTHELIUM IN MUCOUS MEMBRANES. He states that on the surface of the intestinal mucous membrane there are two layers, of these one is superficial, and is composed of cylindrical glandular epithelium. It clothes the villi and is prolonged into the glands. The other is subjacent to this and presents all the characters of an endothelium lining a blood-vessel or a lymphatic cavity. It envelopes the villi, is prolonged into the glands, is composed of thin cells, the sinuous irregular margins of which dovetail into each other, and it forms their membrana propria. But the presence of a sub-epithelial endothelium is not confined to the intestine, for he has also demonstrated its existence in the mucous membrane of the bladder and trachea, and he is of opinion that the endothelial cells of the latter are continuous with the cells lining the pulmonary vesicles.

TONGUE.—A. Hoffman describes the DISTRIBUTION OF THE GUSTATORY BODIES in the human tongue (*Virchow's Archiv*, LXII. 516). He finds them on all the circumvallate papillæ; on the fungiform papillæ; on the papillæ foliatæ, or gustatory lamellæ, as they have been named by W. Turner, *i.e.* the lamellated arrangement of the mucous membrane of the tongue situated at the sides of the root of the organ; on many of the larger papillæ of the soft palate, especially at the upper part of the uvula. They are found in all places where gustatory sensations can be excited.

LARYNX.—P. Coyne (*Arch. de Phys.*, Jan. 1874) gives the results of his researches into the ANATOMY OF THE LARYNGEAL MUCOUS

MEMBRANE. He affirms that this membrane is formed in a layer subjacent to the epithelium by a reticulated tissue analogous to lymphoid tissue, and that it thus approaches the structure of the mucous membrane of the small intestine. In the superficial part of the mucous lining there are lymphatic organs which correspond to the closed follicles of the small intestine, and he considers that these have some relation to the laryngeal ulcerations so common in the course of certain fevers. Upon the free border of the inferior vocal cords, vascular, and probably nervous papillæ may be found, and these are best developed on the anterior half of the cord, or that part which is the most frequent seat of papillomata. Lastly, he directs attention to the existence of groups of glands which, by their secretion, keep the papillary surface of the vocal cord moist, and thus maintain the integrity of its function.——W. Gruber describes (*Reichert u. du Bois Reymond's Archiv*, 1874, 454) two larynges in which SUPERNUMERARY CRICO-THYROID ARTICULATION existed, and on p. 463, cases in which a supernumerary median process was present on the upper border of the posterior part of the cricoid cartilage, and where supernumerary lateral tubercles were found on the same cartilage. Also on p. 606, a human larynx in which a pair of EXTRA LARNYGEAL SACCULI communicating with the interior of the larynx projected between the hyoid bone and thyroid cartilage. They are analogous, he says, with the extra-laryngeal sacs in the Gorilla and Orang.

TEETH.—Oscar Hertwig contributes (*Archiv für Mikroskop. Anat.* XI. 1874, Supplement) an elaborate memoir, extending to 208 pages, with five plates, on the *skeleton of the buccal cavity*, and on the *dentary system of the Amphibia.*——C. S. Tomes (*Proc. Roy. Soc. London*, Dec. 10, 1874) describes the *development of the Teeth of the Newt, Frog, certain Lizards and the Ophidia.* He holds that there is no dental groove in these animals, but that the development of the teeth takes place beneath an unbroken surface of epithelium, neither is there a stage of free papillæ. His description of the mode of formation of the tooth-germs is not unlike that given by Waldeyer of their development in mammals, an inflection of epithelium forming the enamel organ, whilst an elevation of the sub-epithelial tissue forms the dentine organ. There is no cementum, he says, upon the teeth of snakes——E. Magitot describes (*Journ. d'Anat. et de la Phys.*, Jan. 1875) various *anomalies of number* in the dentition of the mammalia, as regards congenital absence, numerical diminution or increase.

MALE UTERUS.—ROBIN and CADIAT (*Journ. d'Anat. et de la Phys.*, Janv. et Fev., 1875—Mars et Avril, 1875) write upon THE CONSTITUTION OF THE MUCOUS MEMBRANE OF THE MALE UTERUS, OF THE VASA DEFERENTIA, AND OF THE TRUMPET-SHAPED ENDS OF THE FALLOPIAN TUBES. They describe (1) the elastic system enveloping the male uterus, and the ejaculatory ducts, (2) the structure of the male uterus, its mucous membrane, and its alveoli, (3) the calculi of the male uterus and verumontanum, (4) the structure of the ejaculatory ducts, of the vasa deferentia, of the trumpet-shaped ends of the Fallopian tubes.

UTERUS.—John Williams describes (*Proc. Roy. Soc. London*, April 30, 1874, and *Obstetrical Journal*, March, 1875) the STRUCTURE OF THE UTERINE MUCOSA, and its periodical changes. The object of the research is to trace the changes which take place in the mucosa, between the cessation of one menstrual flow and the cessation of the next following. The uteri of twelve women, who had died in different stages of the menstrual or intermenstrual period, were examined. During menstruation the mucosa is destroyed by a process of fatty degeneration of its anatomical elements, and the muscular coat is exposed. Three days after the cessation of the flow the mucosa reappears as a very thin pale layer limited to the lower two-thirds of the body of the uterus, and covered by a columnar epithelium the cells of which were $\frac{1}{5000}$ inch in length; glands also were visible, and a layer of round and fusiform cells intervened between the muscular coat and the surface. Six days after the cessation of the discharge the mucosa of the body of the uterus is very thin (about one line at its thickest part), congested, glands in great part without epithelium, and only in their deep ends can columnar epithelium be seen: no epithelial lining to uterus. At a longer interval after menstruation the mucosa is thicker and well demarcated from the muscular coat, and its glands distinct. When menstruation is imminent the mucosa is thick, smooth, very soft, and contains innumerable vessels. When menstruation has existed one day, the mucosa exhibits excavations, its surface is pale and flocculent, the vessels highly congested and torn across, glands disintegrated, epithelium absent or fatty. On the fifth day of menstruation the mucosa had been in great measure removed, beginning, as in the other specimens, at the os internum, and spreading to the fundus. In another case where the menstrual flow had not quite ceased at the time of death the mucosa above the os internum was entirely absent. The menstrual flow, according to Williams, is not a process complete in itself, but the terminal change of a cycle of changes which begins at the cessation of the period, passes through the developmental changes of the mucosa, and ends with the cessation of the flow next following. Hence there is no period of uterine rest. The flow of blood is due to the vessels of the membrane undergoing fatty degeneration, and then giving way, the membrane then disintegrates, and is removed cell by cell, beginning at the os internum and proceeding to the fundus. The new mucosa begins to form near the os internum and gradually proceeds to the fundus: it proceeds from the inner layer of the muscular wall by proliferation, the muscular fibres producing the fusiform cells, the connective tissue the round cells, and the groups of round cells in the meshes formed by the muscular bundles the glandular epithelium.

OVARY.—Jas. Foulis communicated, as a graduation thesis presented to the Medical Faculty, University of Edinburgh, April, 1874, and to *Proc. Roy. Soc. Edinb.*, Dec. 21, 1874, a paper on THE

DEVELOPMENT OF THE OVA, AND THE STRUCTURE OF THE OVARY, IN MAN AND OTHER MAMMALS. After an historical introduction, in the course of which the author gave an abstract of the important observations of Pflüger and Waldeyer, he proceeded to state his own observations on the development of the ova and structure of the ovary in calves, kittens, and the human female. The corpuscles of the germ epithelium are derived by direct proliferation from those columnar corpuscles which invest the median side or surface of the Wolffian body, and which are continuous with the layer of columnar corpuscles that lines the pleuro-peritoneal cavity of the embryo in the early stages of development. The stroma of the ovary in the early stages of development is produced by a direct growth out from the interstitial tissue of the Wolffian body immediately beneath the germ epithelium on the median side of the Wolffian body. The germ-epithelial corpuscles proliferate by fission. In the human fœtal ovary of $7\frac{1}{2}$ months they measure $\frac{1}{2500}-\frac{1}{2000}$ of an inch in their longest diameter, and about $\frac{1}{3500}$ of an inch in their shortest diameter. Each germ-epithelial corpuscle is a nucleus surrounded by a thin film or investment of clear protoplasm. The nucleus of each germ-epithelial corpuscle becomes the germinal vesicle of the mature ovum; and every germ-epithelial corpuscle is potentially an ovum. In the act of becoming primordial ova, the nucleus of each germ-epithelial corpuscle swells up into a spherical corpuscle with dark granular contents, within which is generally seen a nucleolus, and around which is produced clear homogeneous protoplasm, which subsequently forms the yelk of the ovum. Germ-epithelial corpuscles are seen in all stages of development into primordial ova. In each primordial ovum the spherical germinal vesicle presents a sharply defined limiting membranous wall. Within the germinal vesicle is the nucleolus or germinal spot. All the ova in the ovary are derived from germ-epithelial corpuscles. In all parts of the ovary processes of vascular connective tissue stroma grow in, between and around certain of the germ-epithelial corpuscles, whereby the latter become more and more embedded in the stroma of the ovary. Germ-epithelial corpuscles are being constantly produced on the surface of the ovary, to take the place of those already embedded in the stroma. The embedded corpuscles increase in number by division, and the nucleus of each swells up into a spherical germinal vesicle, around which is gradually produced the yelk of the ovum. In all parts of the young ovary under the germ-epithelium, groups of germ-epithelial corpuscles become embedded in meshes of the stroma. As each individual in the group swells up the nucleus or germinal vesicle of each becomes very distinct as a round or spherical body. From the swelling out of each germ-epithelial corpuscle in the group, the whole group expands and becomes more or less spherical. Such groups of developing corpuscles are called egg-clusters. Each egg-cluster is enclosed in a mesh or capsule of vascular stroma of the ovary. The stroma of the young ovary consists for the most part of fusiform connective-tissue corpuscles and blood-vessels. The walls of the young blood-vessels in the young stroma consist of connective-tissue corpuscles. These connective-tissue .corpuscles are direct offshoots from the ovarian stroma, and are found in contact with the yelk or protoplasm of each primordial ovum situated among the germ-epithelial corpuscles on the surface of the ovary. Wherever we find primordial ova we see connective-tissue corpuscles in contact with the yelk of each. In all parts of the ovary we find the nuclei of connective-tissue corpuscles dividing. Sometimes these corpuscles are swollen out into round bodies containing three to four nuclei. In each egg-cluster several of the included germ-epithelial corpuscles are in a much farther advanced stage of development than their fellows. From the walls of the meshes enclosing the egg-clusters, delicate processes of vascular connective tissue grow in, between, and around individual corpuscles in the egg-clusters, and by a continued intergrowth of the young stroma in this manner each individual of the group becomes at last enclosed in a separate mesh or capsule. These last-formed meshes are the Graafian follicles. As a rule, each Graafian follicle is occupied by one young ovum. The protoplasm or yelk of each ovum is in close contact with the wall of each Graafian follicle. In contact with the yelk of each young ovum, and indenting it, are connective-tissue corpuscles, which form part of the wall of each Graafian follicle. In the formation of the membrana granulosa, these connective-tissue corpuscles in the wall of the Graafian follicle, and in contact with the yelk of the contained ovum, increase in number by division, their nuclei swell out into little vesicles, and at last a perfect capsule of such corpuscles is produced round the ovum. This capsule is the membrana granulosa or follicular epithelium of the follicle. At first the membrana granulosa consists of a simple layer of cells lining the follicle. The individual corpuscles of the membrana granulosa measure about $\frac{1}{3000}$ inch. As the ovum becomes mature, the corpuscles of the membrana granulosa proliferate, and then many layers of small corpuscles are produced between the ovum and the follicular wall. The cells of the membrana granulosa are thus derived from the corpuscles of the connective-tissue stroma, and not, as Waldeyer states, from the germ-epithelial corpuscles. The follicular space is formed by a breaking down and probable solution of certain of the corpuscles of the thickened follicular epithelium in the middle parts of the same. The discus proligerus consists of follicular epithelial corpuscles, which are in contact with the zona pellucida of the ovum. The zona pellucida or vitelline membrane is formed by a hardening of the outer part of the yelk or protoplasm of the ovum, and is not, as Reichert, Pflüger, and Waldeyer stated, a product of the follicular epithelium. At birth the human ovary contains not less than 30,000 ova, few of which reach maturity. In the human ovary at birth the germinal vesicles measure $\frac{1}{1500}-\frac{1}{1200}$ of an inch. Most of them are about the same size, and also present a sharply-defined membranous wall. In some germinal vesicles two or three germinal spots are seen. The tunica albuginea is the thickened stroma growing round the ovary. At the age of 2½ years all formation of ova from the germ-epithelium has ceased. Graafian follicles are not formed from tubular structures in the manner described by Pflüger, Spiegelberg, and

Waldeyer. The appearances of tubular structures in the human ovary passing into its stroma are produced by sections through furrows and depressions between irregular prominences on the surface of the fœtal ovary. The irregularities of the surface of the fœtal ovary are produced by the expansion of egg-clusters upwards under the germ epithelium. When the walls of furrows and depressions come in contact, egg-clusters are formed by the embedding of germ-epithelial corpuscles in that situation, just as in other situations. Egg-clusters are formed in connection with the germ-epithelium lining the furrows and depressions. Among the germ-epithelium corpuscles lining the furrows, &c., we find large primordial ova, and corpuscles in all stages of development into the same, just as in other situations among the ordinary germ-epithelial corpuscles. In the kitten and bitch strings of ova still communicating with the superficial germ-epithelium have been interpreted by some observers as if they were tubes filled with cells. At the age of six years the epithelium on the human ovary consists of very small flat hexagonal-shaped corpuscles, measuring $\frac{1}{2500}-\frac{1}{3200}$ of an inch. The corpuscles are seen dividing. This layer can be stripped off without difficulty. At the age of twelve the epithelium has little difference in appearance from the above, the small size of the epithelial corpuscles being remarkable. The epithelium is beautifully seen in old cats, and must be regarded as homologous with the peritoneal epithelium. In old cats the epithelium on the surface of the ovary consists of very small distinct cells, measuring from $\frac{1}{1800}$th to $\frac{1}{2000}$th inch, with granular oval nuclei.——A. Kölliker concludes (*Verh. der Würzb. phys.-med. Gesell.* VIII., May, 1874), from recent researches made on the ovaria of newly-born and a few-days-old bitches, that the MEMBRANA GRANULOSA HAS A DIFFERENT ORIGIN FROM THE OVA. The ovaries of 1—2 days-old bitches present two very different constituents. Round about the cortical zone are found heaps of primordial ova (Pflüger), in longish, oval and round clusters, simply surrounded by stroma ovarii, egg near egg, without any structure between them. In the interior of the ovary a large number of slender strings of cells are found separated here and there, of a mean diameter of 20—30 μ, and composed of roundish cells without nuclei, which proceed everywhere from the locality of the mesovarium towards the cortex of the ovary. On following up the above-mentioned cellular strings towards the cortex ovarii, Kölliker arrived at the clear conviction that they were connected with the groups of primordial eggs of the cortex, the egg-tubes of Pflüger, and that in these places the cells of the medullary strings formed envelopes around large and small numbers of primordial eggs, in such a manner that this cellular covering was completely developed around the deepest-lying eggs, whereas around the outermost eggs it became more and more imperfect, till at last the small cells disappeared amongst the primordial eggs. The observations which he made regarding the connection of the medullary strings with the egg-tubes, or clusters of primordial eggs, and the gradual appearance of the membrana granulosa at the bottom of the tubes, he interprets in this way, that the cells of the membrana granulosa are furnished by the medullary strings, and that these strings by continued increase of their elements are pushed forwards gradually to the superficial egg-cells, surrounding the latter with cells; consequently ovum and membrana granulosa have a different origin. Kölliker concludes by stating his opinion that these cell-strings have their origin in the Wolffian body.

EMBRYOLOGY.—A. Kölliker communicates (*Verh. der phys.-med. Gesellsch. Würzburg*, Jan. 1875) observations on the GERMINAL LAYERS IN THE HEN'S EGG. From observations made on the blastoderm of the impregnated ovum and on the white yelk, more especially from the behaviour of the nuclei to osmic acid, acetic acids, and carmine, he concludes that they are quite different and definitely distinct formations. The increase in thickness in the superficial part of the blastoderm is due to repeated fission of its cells; this increase leads in the 10th—12th hour of incubation to the formation of the middle germinal layer. He does not agree with those authors who describe the middle layer as arising from the edge of the blastoderm, but he regards this layer in the middle of the blastoderm, in the neighbourhood of the later-appearing primitive streak and embryonic axis, as arising from the ectoderm, by an increase of the cells of the same; the mesoderm, having become more strongly developed, represents the inferior part of the so-called primitive streak. He considers that in this streak the ectoderm and mesoderm are not grown together, but from the first appearance of this axial thickening form one mass, which subsequently resolves itself into two layers; the entoderm has certainly no share in the formation of the primitive streak. From repeated inquiries Kölliker has come to the conclusion that the whole of the mesoderm at its first appearance arises at the expense of the cells of the axis-plate, the deeper parts of which grow at its borders between ectoderm and endoderm towards the border of the area pellucida. When the axis-plate has been separated into chorda, medullary plate, primordial vertebral plates, the entire growth of the mesoderm on the surface and in thickness is due to an uninterrupted increase of its elements. The determination that no part of the mesoderm arises from the endoderm has cost much labour, as at first sight there is much to say in favour of such a development at the borders of the mesoderm; but the invariable appearance in the first instance of the mesoderm in the middle of the area pellucida, its slow growth towards the border of this area, its separability at all stages from the endoderm, lead to the conclusion that the middle germinal layer has no genetic connection with the endoderm. The thickening or "Keimwulst" at the edge of the area pellucida belongs to the endoderm, and presents a division into an inner thicker and an outer thinner portion; the cells of the "Keimwulst" are distinctly nucleated. A surrounding or penetration of the elements of the white yelk by these cells does not take place, both parts remain distinct; the appearance of a blending is due to the cells of the "Keimwulst" soon after incubation containing large granules and globules like those of the globules of the white yelk; but the globules of the cells of the "Keimwulst" are produced within them. Hence the elements of the "Keimwulst" are simply cells of the endoderm. The blastoderm of the chick is a two-layered disc. The disc is then converted into a closer vesicle by the growth of the ecto- and endoderm around the yelk. This vesicle is the homologue of the "Keimblase" germ-vesicle in the mammalia, and like it becomes three-layered by the development of the mesoderm.——Hans Virchow, who has worked with Kölliker, contributes (*Virchow's Archiv*, LXII., 566) some observations on the THIRD GERMINAL LAYER in the region of the yelk-sac in the hen's egg, from the middle of the 1st to the 8th day.——E. Ray Lankester details his observations (*Quart. Jour. Microsc. Sc.* Jan. 1875) on the DEVELOPMENT OF THE CEPHALOPODA.

HISTOLOGICAL PROCESSES.—Ranvier (*Arch. de Phys.*, Nov., Dec. 1874) contributes observations upon THE APPLICATIONS OF PURPURINE TO HISTOLOGY. This material is a colouring principle obtained from madder. He gives the following instructions for its preparation for microscopic purposes. A half per cent. solution of alum in distilled water is boiled in a porcelain capsule, and a small quantity of powdered purpurine, with a little distilled water, added to it. If any of this remains undissolved it must be removed by filtration. Alcohol is the next ingredient, and this must be equal in quantity to one-fourth the volume of the whole mixture. He has employed this solution for the tinting of cartilage, bone, cornea, connective tissue, nervous tissue, and the retina, and he gives the results of each of these investigations in detail. In cartilage the nuclei were coloured red, the matrix presented a delicate rose tint, and the cellular protoplasm was transparent. He states that during the growth of cartilage the purpurine shews very plainly the signs of multiplication of the nuclei. In the cornea the fibrillary substance and the cellular protoplasm were not coloured, whilst the nuclei assumed a red tint. Here then, he points out, is a great advantage which the purpurine has over carmine, for the latter colours the fibrillary substances so deeply that the nuclei are obscured. He gives a minute description of these nuclei and also of their mode of multiplication by segmentation in artificially produced inflammation of the cornea. In muscular aponeuroses the flat nuclei applied upon the surface of the bundles were alone coloured, and in bone the osseous corpuscles, but not the basis substance. He obtained, however, the most remarkable results in the nervous system. In sections of the spinal cord, hardened in bichromate of ammonia, the nerve-cells and their poles, the axis cylinder, and the connective-tissue fibres presented no coloration, whilst on the other hand, the nuclei of the epithelial cells lining the central canal, the nuclei of the connective tissue, and the nuclei of the capillaries were coloured red. These nuclei are rendered so distinct that he has been able to count them and give their relative numbers both in the grey and in the white matter of the cord. He states that in every square mm. of grey matter there are 1875 nuclei of the connective tissue and the capillaries, whilst in a similar area of white matter we only find 625.

In the retina the granules of the external and internal granular layers were coloured bright red, and he is thus led to believe that these are not composed of nervous elements properly so called.——Ranvier, in the same number of the same *Journal*, contributes a memoir upon THE USE OF DILUTE ALCOHOL IN HISTOLOGY. He states that alcohol diluted with two parts of distilled water has a most important action on the cellular protoplasm. It fixes the cells in their proper shape, and increases their solidity by coagulating their albuminoid protoplasmic contents. Its action upon the intercellular elements is different. These are softened and macerated, and thus the hardened cells can be isolated with the greatest ease without destroying their original shape in the process. Further, the dilute alcohol modifies the optical characters of the coagulated protoplasm, and brings into view very distinctly the nuclei which this protoplasm contains. It also fixes these nuclei in their original shape. Lastly, he shews that dilute alcohol does not change the affinity of histological elements for colouring materials, as we can obtain after its action the best results with the most delicate colouring agents.——Gustav Fritsch describes (*Reichert u. du Bois Reymond's Archiv*, 1874, 442) a new modification of the MICROTOME of Rivet.——E. A. Schäfer describes (*Quart. Journ. Microsc. Sc.* Oct. 1874) an apparatus for maintaining a CONSTANT TEMPERATURE under the microscope.—In the same *Journal*, Jan. 1875, Golding Bird recommends the use of ELDER PITH as an imbedding material for cutting sections.

COMPARATIVE ANATOMY.

ANTHROPOID APES.—Alex. Macalister describes (*Proc. Roy. Irish Acad.* 1873) the muscular anatomy of a young female *gorilla.*

LEMURS.—In a paper on *Lepilemur* and *Cheiro-galeus* (*P. Z. S.* May 20, 1873) St George Mivart figures and describes the skull and other parts of the skeleton. He reviews the evidence and opinions recently advanced regarding the zoological rank of the Lemuroidea, and maintains that the order Primates is natural and definite, and that it would be a questionable step to raise these animals to a higher value than that of a sub-order.

RODENTIA.—W. C. H. Peters describes *Dinomys* (*Festsch. der Gesellsch. Naturf. freunde zu Berlin*, 1873), a new genus of rodents from Peru.

CETACEA.—J. E. Gray (*Ann. Nat. Hist.* Nov. 1873) objects to the interpretation placed by van Beneden on the drawings of two Cetacea from the Cape of Good Hope.——P. J. van Beneden makes some observations (*Acad. Roy. de Belgique*, June, 1874) on the *Baleen Whales* of New Zealand.——E. van Beneden describes (*Mém. de l'Acad. Roy. de Belgique*, XLI.), by the name of *Sotalia brasiliensis*, a new dolphin from the Gulf of Rio Janeiro.——Julius Haast records (*Proc. Zool. Soc.* May 5, 1874) a new species *Euphysetes pottsii*, a remarkably small species of Catodont whale on the coast of New Zealand.——A. W. Malm communicates (*Kongl.

Vet. o Vitt. Samhällets i Göteborg Hand. 1873) some zoological observations which contain notices of *Delphinus phocæna*, with a figure of a gravid specimen.——C. F. Lütken describes (*Vidensk. Selsk. Skr.* Copenhagen, 1873) the *Cyami* which infest the Cetacea.

PINNEPEDIA.—Jas. Murie continues his researches on the *Descriptive Anatomy of Otaria Jubata* (*Trans. Zool. Soc.* VIII.). This memoir contains an account of the skeleton and the changes in the form of the skull; the nervous system; sensory apparatus; vascular system; hyo-laryngeal and respiratory organs; digestive system; urino-generative organs. As with the previous memoirs by this author on the Pinnepedia, it is beautifully illustrated by well-executed plates. ——J. W. Clark discusses (*Proc. Zool. Soc.* Nov. 18, 1873), the characters of the *Seals of the Auckland Islands.*——J. E. Gray describes (*Proc. Zool. Soc.* Dec. 1873) the crania of seals from Japan, and refers one specimen to a new species *Eumetopias elongatus.*

CARNIVORA.—J. W. Clark records the finding (*Proc. Zool. Soc.* Dec. 2, 1873) of the skull of a *Marten* in Burwell Fen, Cambridgeshire.——A. Macalister describes (*Proc. Roy. Irish Acad.* 1873) the muscular anatomy of *Viverra Civetta*, which he compares with that of the Tayra (*Galera barbata*): also an account of the *myology* of *Aonyx leptonyx.*

EDENTATA.—Jas. Murie describes the anatomy of the three-banded armadillo (*Tolypeutes conurus*), (*Trans. Linn. Soc.* XXX.). After some introductory remarks on its habits, he gives the external measurements, describes the apparatus for drawing the body together, and then gives an account of the viscera, the muscles and the skeleton. Seven well-executed quarto plates illustrate the memoir.

PACHYDERMATA.—Alex. Macalister describes (*Proc. Roy. Irish Acad.* 1873) the anatomy of the Liberian hippopotamus (*Chæropsis Liberiensis*).

BIRDS.—W. Dönitz describes in *Reichert u. du Bois Reymond's Archiv*, 1873, 357, the cervical vertebræ of birds of the genus PLOTUS. ——St George Mivart describes (*Trans. Zool. Soc.* VIII.) the axial skeleton of the ostrich (*Struthio camelus*).——J. Murie, in *Proc. Zool. Soc.* June 16, 1874, shews that the sacs vomited by hornbills consist of the epithelial lining of the gizzard; and on the same date he describes the skeleton of *Fregilupus varius*, which he compares with that of allied genera, and comes to the conclusion that this bird has a close alliance with the Pastoridæ.——A. H. Garrod describes (*Proc. Zool. Soc.* May 6, 1873) the arrangement of the *carotid arteries in birds*, with the view of forming an estimate of their significance in classification; and on June 17th, 1873, and Feb. 3, 1874, he examines certain *muscles of the thigh of birds* with reference to their value in classification. The muscles are tensor fasciæ, biceps cruris, semitendinosus, semimembranosus, ambiens, and femoro-caudal. On June 3, 1873, Garrod describes the anatomy of *Steatornis caripensis*, and on May 5, 1874, some points in the anatomy of

Columba.——R. Owen continues (*Trans. Zool. Soc.* VIII. part 6) his researches on the *Osteology of Dinornis.* The memoir contains a description of a femur indicative of a new genus of large wingless bird (*Dinornis Australis*) from a post-tertiary deposit in Queensland, Australia.

REPTILES.—In a paper on the genera of turtles (*Oiacopodes*) J. E. Gray communicates (*P. Z. S.* April 1, 1873) observations on their skeletons and skulls, and on p. 392 a note with figures on the skull of *Sternothaerus.*——Alfred Sanders describes the *myology of Phrynosoma coronatum* (*Proc. Zool. Soc.* Jan. 6, 1874), and illustrates his observations with a number of excellent woodcuts.

BATRACHIA.—T. H. Huxley describes (*Proc. Zool. Soc.* Mar. 17, 1874) the structure of the skull and heart of *Menobranchus lateralis.*

FISH.—R. H. Traquair describes in *Geological Magazine*, Dec. 1873, a new genus (*Ganorhynchus Woodwardii*) of fossil fish allied to the order Dipnoi: and in the same *Magazine*, June, 1874, he describes *Cycloptychius carbonarius* from the Staffordshire coal-measures. He also gives an account, in *Ann. Nat. Hist.* April, 1875, of the structure and systematic position of *Cheirolepsis*, and describes some fossil fishes from the neighbourhood of Edinburgh, as *Nematoptychius Greenockii, Wardichthys cyclosoma, Rhizodus Hibberti.*——The Bakerian Lecture on the *Structure and Development of the Skull in the Salmon*, by W. Kitchen Parker, is in *Trans. Roy. Soc. Lond.* 1872.——Ranvier (*Arch. de Phys.* Jan. 1874, 17) contributes a short memoir upon THE MUSCLES OF THE DORSAL FIN OF THE HIPPOCAMPUS. He states that the peculiar vibratory movement of this fin is satisfactorily explained by a study of its muscular apparatus. The bony case which contains the muscles is divided into two lateral parts by a longitudinal partition, upon each side of which small conical muscles are placed. On removing one of the sides of this bony case these muscles with their nerves and vessels are readily seen, as they are embedded in a perfectly transparent mucous tissue. The primitive fasciculi, of which the diameter is at least $\frac{5}{100}$ of a mm., possess a sarcolemma which is placed at some distance from the mass which constitutes the bundle, and in the space intervening between the two there is a granular material containing large nuclei Each muscular bundle is provided with a distinct tendon, and the tendon of the entire muscle is formed by the union of all these little tendons. He states that the muscular fasciculus terminates in a blunt cone with an irregular surface. The tendon, which is much smaller in diameter than the fasciculus, enlarges at its extremity into a hollow cone, which fits exactly upon the solid cone formed by the muscular bundle. The granular mass within the sarcolemma stops abruptly at the point of union of the tendon and muscle, and he points out that it is probable that the sarcolemma ends with it.

REPORT ON PHYSIOLOGY. By WILLIAM STIRLING, D.Sc., M.B., C.M., *Demonstrator of Practical Physiology in the University of Edinburgh*[1].

Nervous System.

ON THE ELECTRICAL EXCITABILITY OF THE SURFACE OF THE CEREBRUM.—O. Soltmann, in a preliminary communication to the *Centralblatt*, No. 14, 1875, sums up his results thus. (1) No muscular movements are produced by electrical stimulation of the surface of the cerebrum in newly-born dogs. (2) These movements were first noticed several days after birth (9—11 days). (3) The extent and form of the motor areas vary, they are different in young animals from those in the adult.

MOTOR FUNCTIONS OF THE CEREBRUM.—M. Schiff, *Arch. f. Exp. Path. Pharmak.* 1874, III. 171. According to Schiff the so-called motor centres of the cortex of the cerebrum are reflex centres. Supporting this view is the fact that when the animal is deeply narcotized, galvanic stimulation of a "motor centre" is without effect, even when with decrease of the narcosis painful stimulation produces movements. By keeping up artificial respiration and rapidly increasing it, one can throw the animal into a condition resembling death; the reflex movements cease, and the stimulation of the cortex is without effect. After the return of the spontaneous respiration the stimulus again acts. According to Fritsch and Hitzig induction currents do not produce tetanic contractions in the muscles dependent upon the stimulated area, and this, according to Schiff, shews that one has to deal with a sensory centre. In opposition to the action in motor parts, on stimulating the centres in the cortex the closing inductive shock acts *before* the much stronger, but much more rapid opening shock. On interrupting a galvanic current with an interrupting-wheel, and on stimulating the lumbar spinal cord, a contraction was produced when the duration of the current was $\frac{1}{3000}$ th of a second, whilst for the cortex of the brain $\frac{1}{208}$ th of a second was necessary, *i.e.* a duration of the current ten times longer. It was also found that on stimulating the centres in the cortex, seven to eleven times longer time elapsed before the muscles dependent upon the ischiadic nerve contracted, taking simply the greater distance into account, than ought to have elapsed if it was simply a motor part, *i.e.* when compared with the time which elapsed between stimulation of the roots of the Nv. ischiadicus and the contraction resulting therefrom. Lastly, Schiff confirms the fact observed by the first experimenters (F. and H.), that extirpation of single cortical centres is followed by loss of the "muscular sense." The author does not believe in the

[1] To assist in rendering this Report more complete, authors are invited to send copies of their papers to Dr Stirling, Physiological Laboratory, Edinburgh University.

existence of motor centres for the muscles of animal life in the cortex of the brain, but he thinks we must assume their existence for the movements of the heart, in that stimulations of, till now not previously defined parts of the cortex, influence the movements of the heart, that this influencing seems to be the expression of a direct excitability, and no reflex phenomenon.

On the Functions of the Lumbar Portions of the Spinal Cord of the Dog.—Eckhardt concluded from the fact that erection could be produced by electrical stimulation of different parts of the brain that the centre for erection lay in the brain (*Journ. of Anat. and Phys.* VIII. 186). F. Goltz and A. Freüsberg (*Pflüger's Archiv*, Vol. VIII., and abstract in *Centralblatt für die Medicinischen Wissenschaften*, No. 41) shew, however, that in dogs several days after section of the spinal cord at the limit between its lumbar and thoracic portions, that by certain stimulations of different peripheric portions of the body erections occur reflexly, and this very regularly. If, however, the lumbar spinal cord be destroyed, the erection does not take place. Just as the activity of other reflex centres can be inhibited by strong stimulation of the central ends of sensory nerves, so also is the lumbar centre for erection. Of course this centre can be inhibited as well as excited through fibres which pass to it from parts higher in the spinal cord or from the brain. Thus is to be explained the fact that after peripheral stimulation erection does not occur so promptly in intact animals as in those with divided thoracic spinal cord; and on the other hand the observation of Eckhardt and others, that erection follows stimulation of certain parts of the brain, is also explained. According to the authors there is also present in the lumbar spinal cord a reflex centre for the evacuation of the urinary bladder. For, when in dogs the spinal cord is destroyed at the limit between its lumbar and thoracic portions, gentle tickling of certain peripheral parts of the body produce evacuation of the urine. The authors also believe that even in the waking state in man, originally the activity of the bladder is excited, not by the will, but reflexly from the mucous membrane of the bladder, whereby the first drop of urine enters the urethra. The further evacuation, however, can be continued afterwards by stronger innervation of the constrictor partis membranaceæ urethræ. This centre also stands in connection with the brain through inhibitory and exciting fibres. By analogous experiments, the authors shew that the sphincter ani can also be excited reflexly to peculiar rhythmical activity, whilst the rectum exhibits peristaltic movements, and that the centre for these reflex acts also lies in the lumbar spinal cord. Goltz shewed, ten years ago, that in the frog the spinal cord exerts an influence on the tone of the blood-vessels. Legallois observed the same fact on rabbits, though he explained it incorrectly. The authors confirm the observation on the dogs on which they had experimented, that immediately after section of the spinal cord the hind feet become warm, but several days later, after the wound of the operation had quite healed, gradually the former tone returns.

According to the authors this can only occur under the influence of one or more centres placed in the lower part of the spinal cord, which become paralysed immediately after the operation, but gradually again become active. If the lumbar spinal cord be now again injured, an increase of temperature in the hind-feet is again observed. After complete destruction of the lumbar spinal cord, the circulation is so affected that the animal dies. In a supplement, the author adds the remarkable fact, that section of one ischiadicus in a dog also produces, in the leg supplied by it, increase of temperature, even when the spinal cord is completely destroyed. In another communication on 'The Dilating Nerves of Vessels,' Goltz and Freusberg (*Pflüger's Archiv*, Vol. IX.) deduce from their experiments: 1. The existence of local nervous mechanisms placed at the periphery, which govern the tonus and which regulate to a certain extent the blood-circulation; 2. The presence of vaso-dilator nerves in the sciatic nerve, which can be set in activity, either by simple section alone, and then by electrical and chemical stimulation. These facts lead Goltz to regard the increase of temperature which follows section or stimulation of the nerves or of the spinal cord, not as a passive phenomenon, or produced by paralysis of the nerves, but as an active phenomenon.

Drs F. Putzeys and F. Tarchanoff, at Goltz's request, undertook to investigate this subject (*Centralblatt*, No. 41).

A. The first point these authors investigated was: In what relation does the condition of the vessels stand to the temperature of the paralysed limbs?

1. When one sciatic nerve is divided in the thigh in a dog, and the toes on both hind-feet are then cut off, one sees at once that the current of blood which flows out from the paralysed side is very considerable, whilst that on the sound side is very weak or scarcely present. The same result was obtained on young ducks and frogs. The same result was obtained in a frog on division of the roots of the sciatic nerve as they come out of the spinal cord.

2. On stimulating the peripheral ends of the nerves in the animals, these phenomena are completely reversed; the current of blood stops on the paralysed side, and becomes very obvious in the other. Stimulation with common salt gave the same result. These phenomena might be explained by the muscular contraction and tetanus in consequence of stimulation, but the same phenomena were observed in curarised dogs and frogs, but in the frog complete standstill of the outflow of blood did not take place. Direct observation of the vessels immediately after the operation shewed in the duck widening of the vessels, the blood was redder than in the sound foot. Stimulation of the nerves of the paralysed side caused narrowing of the vessels of this side. Microscopic examination shews, that stimulation of the sciatic nerve after its section, either in the thigh or in the pelvis, causes a narrowing of the arteries, which may even go on to complete occlusion of the vessels.

3. If the stimulation be continued for several minutes as under 2, the narrowing disappears, and is followed by widening, which the authors regard as a phenomenon of exhaustion.

On stimulation of a part of the nerve lying more peripherally, the contraction of the vessels can be observed again.

B. 1. Section of the nerve in a dog yielded, just as in Goltz's experiments, considerable increase of the temperature in the corresponding extremity. When, however, the peripheral end was stimulated in a curarised dog, they did not obtain an increase, but a diminution of the temperature, which did not go so far that the paralysed side became as cool as the sound one, but still was 1·5° to 2° C. (2·7° to 3·6° Fahr.). In a duck the sinking was 2·5° C. (4·5° Fahr.).

2. The temperature of the paralysed side in dogs was found after three weeks to be the same as the sound side (corroborating Goltz). The widening of the vessels corresponds to the increase of temperature, and the narrowing to sinking of the same.

C. On dividing the sciatic nerve in a frog, and cutting off the toes of both hind-feet, the blood flows out in greater quantity from the vessels of the paralysed side. After ten days, if a new section of the webs be made, blood drops out from both feet, in about the same quantity. When, however, the spinal cord is divided in the middle of the back, or its lower part destroyed, it is observed that very little or no blood flows out of the paralysed foot, whilst from the other it flows out richly. After several days, the difference between the two sides has almost disappeared. If the section of the spinal cord be repeated in this way, that always several days elapse between the individual operations, then a new increase of outflow of blood is observed from the leg, which still stands in nervous connection with the central organ. These experiments support those of Goltz, and prove that a complete accordance exists between the conditions of filling of the vessels and the heat of the corresponding part of the body, and that the gradual return of the temperature to the normal is the consequence of the restitution of the tonus. The authors derive the following conclusions from their experiments:—

1. The restitution of the tonus of the vessels, which have lost their connection with the automatic centres placed in the brain and spinal cord, cannot be otherwise explained, as Goltz has already suggested, than by the existence of local peripheral arrangements, perhaps of a nervous nature, which they are not disinclined to compare to those which exist in the intestines; the tonus will therefore, in the first instance, depend upon this local mechanism, and secondly, upon the centres in the spinal cord.

2. The sciatic nerve contains vaso-motor fibres.

3. It is not yet proved that it also contains vaso-dilator fibres (after the meaning of Goltz), nerves which, according to the above authors, are unnecessary for the explanation of the different phenomena.

4. Section of the nerves and spinal cord produce, without doubt, a stimulation, whose effect is very evanescent, and which is followed almost immediately by paralysis.

5. The widening of the vessels and the increase of the tempera-

ture, which are sometimes observed immediately after the stimulations, are the effects of over stimulation.

6. One might also add, that the vaso-motor fibres after their section, are in a state of latent irritation, which, in consequence of an energetic stimulation, makes way for exhaustion. One does not therefore require the aid of vaso-dilator nerves to explain the increase of temperature which is observed after stimulation of a divided nerve, or of repeated division of the same.

[In these various papers the authors do not cite the observations of Mr Lister, "On the Parts of the Nervous System regulating the Contraction of the Arteries." *Philosph. Trans.* Part II., 1858, 607. Rep.]

On the 'Spasm-Centre' of the Frog and its Relation to certain Drugs.—F. Heubel (*Pflüger's Archiv*, Vol. IX., and Abstract in *Centralblatt für die Med. Wissenschaften*, No. 59, 1874) remarks that the tonic form of contraction occurring in the frog has been more studied than the more seldom-occurring clonic convulsions. Former investigations had not rendered it certain whether there existed in the central nervous system a circumscribed spot whose stimulation was followed by general clonic spasms. The exposed nervous centres of strong frogs were stimulated by simple, more or less gentle, contact with the head of a needle. Stimulation of the cerebrum, of the thalami optici, of the cerebellum, never gave muscular contractions; that of the corpora quadrigemina produced movements of the eyes, of the membrana nictitans, and bending of the head forwards and downwards. If one touch, by means of the head of a needle, the anterior broad part of the upper surface of the medulla oblongata (sinus rhomboideus), the frog shews, as 'an unmistakable sign of pain,' a sudden powerful contraction of the whole body, so that after removal of the needle the animal lies spasmodically flat upon the table. It remains for a longer or shorter time in a comatose condition, which sometimes passes into death. More sensitive by the same method of stimulation was the posterior angle (that nearer to the spinal cord) of the sinus rhomboideus. Upon touching this spot, the animal constantly uttered a loud cry, followed by trismus, general convulsions, clonic mixed with tonic spasms, whereby all muscles were thrown into action, the animal being caused to roll over, and it continued to contract upon the table. After the spasmodic seizure had passed off, the frog remained a short time in the very remarkable position, until almost completely motionless, and reflex sensibility had almost disappeared. If the animal recovered, the collective symptoms could again be produced, but not with the same intensity. The same results were obtained if, before the stimulation, the medulla oblongata, cerebrum, thalami optici and corpora quadrigemina were removed; sometimes also by a simple section through the medulla oblongata, which probably acted as a stimulus to the hypothetical spasm-centre (*Krampf-centrum*). As the anterior limit of this centrum may be indicated an imaginary line which divides the sinus rhomboideus into an anterior and posterior half, whilst the posterior limit certainly does not lie more than one or one and a half millimètres (·04 or ·06 inch) behind the calamus scriptorius. Concentrated solution of chloride of sodium also produced general bodily convulsions, which passed into tetanus. It could be proved that the centre for these muscular contractions is to be sought in the medulla oblongata. After the assumption of a special 'spasm-centre' (Nothnagel) was capable of being regarded as probable, the idea that the action of picrotoxin, nicotin, and other bodies upon the organism is caused through this centre, lay at hand. The author corroborates the proofs already offered by Röber, that picrotoxin, in that it produces the characteristic spasms, acts as a stimulus to the ganglionic apparatus of the medulla. The same is also true (contrary to the ordinary assumption) for nicotin. After careful separation of the brain from the spinal cord in the frog, it is said that nicotin spasms no longer take place ; on the spinal cord this alkaloid acts only as a depressant, and to such a considerable extent, that always (when the medulla oblongata is retained) only a single spasmodic seizure is produced, and repetition and increase of the dose do not cause a second attack as by mechanical irritation, and by chloride of sodium, picrotoxin and nicotin. So also by caustic ammonia, carbonate of ammonia, bromide of ammonia, and chloride of ammonium could general clonic spasms be produced whose point of origin was undoubtedly placed in the medulla oblongata. In all the above experiments it remains doubtful whether the spasms were produced reflexly or directly. Several circumstances support the latter view. In all experiments the reflex sensibility was considerably diminished, whilst in undoubtedly reflex spasms (*e.g.* those produced by strychnin) the reflex-sensibility is almost always increased. Further, artificial respiration was without effect on the spasms produced by nicotin, whilst reflex spasms, as is known, are cut short by apnœa. The author adverts to the fact that under strong stimulation of peripheral sensory nerves certain actions of the large nerve-centres are inhibited. Corresponding to this he explains the diminution of the reflex sensibility and of the sensory activities during and after stimulation of the 'spasm-centre,' 'this most sensitive point of the whole cerebro-spinal axis,' as a direct consequence of stimulation of the medulla itself.

"Effects of Alcohol on the Nervous System." Hammond, Abstract in *Lond. Med. Recd.*, No. 98, 1874.——"Recent researches on Vasomotor Nerves." H. P. Bowditch, *Boston Med. and Surgical Journal*, Jan. 1875.——"Physiology and Pathology of the Pyramids of the Medulla Oblongata." Benedikt, *Wiener Medizin. Presse* (Abst. in *Lond. Med. Recd.*, No. 118).——"The development of the powers of thought in Vertebrate Animals in connection with the development of their Brains." D. Byrne, *Jour. of Anat. and Phys.* IX. 97.

"CHANGES OF COLOURATION IN VARIOUS ANIMALS UNDER THE INFLUENCE OF NERVES." Pouchet, *Comptes rendus*, Dec. 21, 1874 (Abst. in *Lond. Med. Rec.*, No. 106). Operation chiefly on fishes, *e.g.* turbots. The colour of several species was observed to change when they were irritated, or on simple sight of an external object. And since the changes depend on the greater or less colouration of light by the bottom, they must be regarded as reflex acts, having their centre in the brain and their starting point in retinal impressions. The fundamental experiment of M. Pouchet is that of suppressing the 'chromatic function' by removing the eyeball, or simply cutting the optic nerve. The blinded animal loses its power of changing colour according to the bottom. Neither the spinal nerves nor lateral nerves govern this chromatic function. The trigeminus has an effect. The great sympathetic is the great governor of this function, and it forms the route of transmission for the influences going from the brain to the cutaneous chromoblasts. The same function exists in some articulata, as *Palemon serratus*.

On trophic and vaso-dilator Nerves.—Cl. Bernard (*Gazette Méd. de Paris*, 1874, No. 13) divided the trigeminus between the Gasserian ganglion and the brain, and obtained the ordinary neuroparalytic ophthalmia, without his being able by the most exact microscopic examination to detect the slightest degeneration of the nerve-fibres. The trophic disturbances are therefore to be ascribed to conditions in the circulation; the Nv. trigeminus encloses a large number of vasodilator fibres, whose section causes paralysis and consequent disturbance of the circulation. With the trigeminus divided as above, even after eight days a considerable secretion of saliva could be produced upon stimulating mucous membrane of the tongue; the stimulus, which in this case affected the lingual nerve, could only be conveyed to the chorda tympani through the intact remaining gang. submaxillare. Former experiments shewed the author that the property of the sub-maxillary ganglion to act as a reflex centre only lasts two or three days after section of the lingual nerve.

General Physiology of Nerves.

"The Polar Action of Electricity in Medicine." John J. Mason, *New York Med. Jour.*, Dec. 1874.——"Note on the so-called Autogenic Regeneration of Nerves." A. Vulpian, *Archiv. de Physiol.* 1874, 704.

On the Terminations of the Gustatory Nerve.—E. Sertoli (*Gazetta Medico-Veterinaria*, Anno iv., Abstract in *Centralblatt für die Medicin. Wissenschaften*, No. 55, 1874) investigated the papilla foliata of the tongue of the horse. For the investigation, the author employed a very interesting modification of the gold method. Small pieces of fresh tissue were placed in a relatively large quantity of gold solution ($\frac{1}{4}$ to $\frac{1}{3}$ per cent.), and allowed to remain therein for eighteen or twenty-four hours, then washed out with water, and placed for eighteen to twenty-four hours in a 2 per cent. solution of bichromate of potash. They were then washed out with water and placed in absolute alcohol, in which they were completely hardened, and in which the colour already begun in the bichromate of potash appeared perfectly. The colour can be accelerated by exposing the preparation in bichromate of potash to a temperature of 30° Cent. (86° Fahr.). The papilla foliata is very richly supplied with nerves. In the subepithelial connective tissue the nerves form a very dense network, and end in the two following ways: (1) in the gustatory bulbs, which are present in extraordinarily large numbers in the folds and furrows of the papilla foliata; (2) in an intra-epithelial network of fine non-medullated nerve-fibres intensly coloured by chloride of gold. In addition to this network stellate bodies coloured dark violet by chloride of gold lie between the pavement epithelium, the bodies being similar to those described by Langerhaus from the human epidermis. Sertoli is inclined to regard them as non-nervous. As this intraepithelial nervous network lies deeply imbedded and protected in the furrows of the papilla foliata, it cannot, according to Sertoli, be regarded as the anatomical substratum of the sense of taste, and he also claims it as a gustatory organ, as the form of termination of the specific sensory nerves of the tongue. In fact, this same intraepithelial nerve-ending, which often penetrates to the most superficial layers of the epithelium, occurs quite commonly in the papillæ fungiformes of the horse's tongue. These papillæ are distributed in great numbers and with great regularity over the whole dorsum of the tongue, and it is very tempting to regard this form of ending as the anatomical condition of the gustatory sense distributed over the whole surface of the tongue. The conclusion of the paper is occupied with the consideration of the minute anatomy of the gustatory discs (which are rendered a very characteristic dark colour with chloride of gold).

Eye.

"On the dependence of perception of Colour on the time." M. Kunkel, *Pfluger's Archiv.* IX. 197 (Abstract in *Lond. Med. Recd.* No. 97, 1874).——"On susceptibility in different parts of the Eye for different colours." Raehlmann, *Graefe's Archiv für Opthalmologie*, XX. Heft. 1 (*Ibid.*).——"On simultaneous Light-contrast." E. Hering, *Sitzungsb. d. Wiener Acad.* No 68 (Abst. in *Lond. Med. Recd.* No. 101). ——"Transplantation of rabbit's conjunctiva to the human conjunctiva." Otto Becker, *Wiener Medizin. Wochenschr.* No. 14, 1874. ——"Method for measuring the refractive power of the crystalline lens." Hirschberg, *Centralblatt*, No. 49 and 52, 1874. Reply to the foregoing, by E. Cyon, *Centralblatt*, No. 50.——Meyer's experiment. J. Hoppe, *Deutsche Klinik*, 1874, No. 32.——"The Colour of the yellow spot in Man." H. Schmidt, *Centralblatt*, No. 57.——"State of the pupil during chloroform anæsthesia." Budin, *Gaz. Méd. de Paris*, 1874, No. 38.——"Pulsatory phenomena within the Eyeball." Jacobi, *Centralblatt*, No. 2, 1875.——"On the action of Muscarin in accommodation and on the pupil." W. Krenchel, v. *Graefe's Archiv. für Ophthal.* 1874, XX. 135 (Abst. in *Centralblatt*, No. 4, 1875).——"On the oblique passages of the rays of light through the lens, &c." L. Hermann, p. 24, pl. 1, Zürich, 1874 (Abst. in *Centralblatt*, No. 11, 1875). "On the Theory of Colour-blindness." F. Holmgren, *Upsala Läkarefor förhandl.* 1874, II. 119, III. 187 (Abst. in *Centralblatt*, No. 15, 1875).

Consequences of section of the Optic Nerve in the Frog. W. Krenchel, v. *Graefe's Arch.* 1874, 127.—Berlin found that after section of the optic nerve in the frog, degeneration of the nerve-fibres to their most extreme intra-ocular terminations occurred. Berlin suggested that this was not due merely to the section of the nerves, but to the division of the blood-vessels by his method of operating. The author confirms Berlin's results completely, and shews further, by intra-cranial section (whereby the vessels are uninjured), the correctness of the above assumption. K. found that in frogs, six months after the operation, no change in the eye either macro- or microscopically was to be detected; on the contrary, he found that several times in the almost always completely divided optic nerve, degeneration of the nerve-fibres for 1 to 2 mm. from the point of section had taken place. It is very remarkable that the mobility of the pupil for the action of light is not in the least diminished by intra-cranial section of the optic nerve.

Influence of section of the Trigeminis on ocular pressure. —Hirschberg (*Centralblatt,* No. 6, 1875) confirms the view of Donders and Snellen, that section of this nerve in man produces after a time decided diminution of the intra-ocular pressure.

On Traumatic Keratitis.—Walb (*Centralblatt,* No. 7, 1875) employed the method of Lieberkühn, viz. the injection of a freshly prepared neutral solution of carmine into the cornea of the rabbit. This causes little or no disturbance, and if the cornea is examined in from 10 to 11 days, the corneal corpuscles are found splendidly coloured and lying in a perfectly colourless ground-substance. Afterwards the cornea can be irritated by chloride of zinc, nitrate of silver, &c., and the changes in the corpuscles, &c., noted.

Goldzieher on Implantations in the Anterior Chamber of the Eye.—W. Goldzieher (*Archiv für Experiment. Pathol. und Pharmak.* 1874, Band xi., Abstract in *Centralblatt für die Med. Wissenchaften,* No. 52) has adopted a method similar to that of Zielenko, who placed in the lymph-sacs of frogs different tissues, and observed the changes they underwent. The author used the anterior chamber of the eye of rabbits, and placed in it conjunctiva, nasal mucous membrane, nerves, cornea, &c., the advantage being that the coarser changes could be continually observed and controlled through the cornea, which almost always remains transparent. He found that the body introduced very soon became attached and vascular, either by the iris or by the conjunctiva, by means of the cicatrix in the limnus corneæ. They became either encapsuled, the iris encircling them like folds, whereby cysts may be formed (so-called epidermoid iris-cysts), or they increase by adhering to some structure in the interior of the eye, and either shrivel or develop further, either in all parts (tuba, which even shewed peristaltic movements), or only in one (epithelium of the nasal mucous membrane). The proliferating epithelial cells do not conduct themselves in the foreign tissues as irregular developing tissues, which destroy the texture of adjoining parts, but conduct themselves after their physiological type.

Ear.

Anatomy of the Ear. Politzer, *Allgem. Wiener Med. Zeitung*, October 20th, 1874——"On the Physiology of Audition. A. M. Meyer, Abstract in *Lond. Med. Recd.*, No. 101.——" On the use of the Membrana Tympani as a phonautograph, *Boston Med. and Surg. Jour.*, 1875 (Absts. in *Lond. Med. Recd.*, No. 115.)——" On section of the Semicircular Canals and the hypotheses founded thereon." A. Bötcher, *Arch. f. Ohrenheilkunde*, IX. 1—71. (Absts. in *Centralblatt*, No. 48, 1874).——" On the connections of the Ossicles of the Ear." G. Brunner, *Knapp and Moos' Archiv.*, 1874, III., 22.——" Temperature of the External Auditory Meatus." E. Mendel, *Kirch. Arch.* LXII., 132, finds, that in the healthy subject the temperature is always 0,1 to 0,3° C. lower than that of the rectum. During apoplectic or epileptic seizures the temp. of the ext. auditory meatus in comparison with that of the rectum is increased. Injection of morphia or narcosis produced by chloral produces considerable diminution of temperature.

Skin.

" On the reflex phenomena connected with the vessels of the skin, and on reflex sweating." Botkin, *Berlin Klin. Wochensch.* Nos. 7 and 8, 1875.

Circulatory System.

" The Blood and Glycæmia." Claude Bernard, *Revue Scientifique*, Nov. 28, 1874.——" The phenomena and functions of Transudations in the animal organism." F. Pacini, *Lo Sperimentale*, Oct. and Nov., 1874.——" Direct stimulation of the Heart in Mammals." S. Mayer, *Sitzungsb d. Wiener Akad.* LXVIII., Heft. 1 to 3. (Absts. in *Lond. Med. Recd.*, No. 104, 1874).——" On the action of Nitrite of Amyl on the Blood-corpuscles." Ladendorf, *Berlin Klin. Wochensch.* No. 43, (Absts. in *Lond. Med. Recd.*, No. 106, 1875).—— " On the function of the Spleen." Tarchanoff, *Lond. Med. Recd.*, No. 107.)——" Modifications of the Blood in its passage through the Spleen." Malassey and Picard, *Comptes rendus*, Dec. 21, 1874. (Absts. in *Lond. Med. Recd.*, No. 117).——"On some points connected with the Circulation of the Blood, arrived at from a consideration of the Sphygmograph-trace." A H. Garrod, *Proceeds of Royal Soc.*, No. 157, 1975.——" Peristaltic Arterial Action." Objections to this theory. J. J. Mason, *New York Med. Jour.* 1873 and 1874.—— " Position of the Heart's impulse in different postures of the body." Ransome, *Jour. of Anat. and Phys.* IX., 137.——" Action of Chloral on the Blood." W. Feltz and E. Ritter, *Comptes rendus*, LXXIX. 1874, 324.——" Transfusion of different bloods." L. Landois, *Centralblatt*, No. 1, 1875.——" Condition of the blood-pressure on respiring compressed Air." Drosdoff and Botschetsch Karoff, *Centralblatt*, No. 5, 1875.——" Transfusion of heterogeneous blood."

L. Landois, *Centralblatt*, No. 1, 1875.——"Mode of action of the Auriculo-ventricular valves." Marc Seé, *Arch. de Physiol.*, 1874 (Abst. in *Centralblatt*, No. 14, 1875).——"Influence of Alcaloids on certain properties of hæmoglobin." Ed. Schär. *Ber. d. d. Chem. Ges.*, VII. 1873, 362.

ON THE CIRCULATION OF BLOOD IN EXCISED ORGANS.—(*Expériences sur la Circulation du Sang dans les Organes Isolés.*) Par Dr Paul Heger, Bruxelles, pp. 69, 8vo. 1873.)—Dr Heger, professor of physiology in Brussels, in an able monograph, cites the results of his researches on the above subject, made under Ludwig's direction. The author shews clearly that the alkaloids have an action, entirely local, upon the walls of the vessels, and that this action is independent of the nerve-centres.

Artificial Circulation. An organ, such as the liver or kidney, is removed from the body as soon as the animal is killed, and a stream of blood passed through its vessels. The study of its function is therefore very greatly simplified. The blood employed ought to be defibrinated, carefully filtered, and brought to a proper temperature, and be taken from an animal of the same species from which the organ, whose function is to be studied, was taken. In certain cases, however, the blood of other animals may be employed, as the blood of the rabbit or the frog, &c. A description is then given of the manner of making articial circulation of defibrinated blood in the lungs of a dog. The lungs are placed in a glass case, hermetically sealed, to represent the thorax; within which the pressure on the surface of the lungs is easily regulated and graduated by a pressure-bottle. Similar instructions are given for artificial hepatic secretions, just as was practised by Asp (*Journ. of Anat. and Phy.* IX. p. 430). The changes that the defibrinated blood undergoes in its passage through the different organs experimented on are then considered.

General Modifications observed in Artificial Circulation. Generally the blood in its passages loses its red arterial colour and takes on a venous character; but if the rapidity of the circulation be considerable, it passes through without alteration of colour. The absolute quantity of oxygen absorbed and of carbonic acid produced is considerable, the relative quantity less. As the chemical modifications are dependent on the rapidity of the current, it is important to study the causes that vary the duration of passage, and establish the relation between pressure and velocity. If organs be devoid of all the properties of living tissues, the pressure being equal, then the quantity of blood obtained at the orifice of outflow will be equal in equal times, save those slight differences which are observed upon operating on inert tubes of small diameter (Poisseuille). But it is not so in a fresh organ in which we cause a current of defibrinated blood to circulate under, *e.g.* a constant pressure of ten millimètres of mercury. The quantity of blood which traverses the organ becomes less from minute to minute, with, however, some oscillations. If, at the moment of cessation of the flow, the pressure in the entering vessels be suddenly elevated by several millimètres, the afflux augments immediately at the orifice of outflow, and, after having attained a maximum, gradually declines. If at the end of the outflow, before it has ceased, the pressure within the entering vessels be suspended, then the current ceases immediately; then, upon restoring the pressure, the current is more considerable than before the interruption. It is seen, then, that (1) every oscillation of pressure causes oscillations in rapidity; (2) under the same pressure the quantities delivered are not equal, since the rapidity diminishes constantly, and a momentary interruption suffices to determine an augmentation of the current. Whilst under a constant pressure the current is established without interruption. On comparing the quantities delivered during two minutes (*e.g.* from the lungs), it happens that the second is larger than the first; there are oscillations such that the rapidity rises, diminishes, rises again and diminishes, until it falls more and more towards zero. In a dead organ the rapidity does not undergo the same oscillations as in a fresh one; in a dead organ (*e.g.* lungs, twenty-four hours after death) the rapidity, at first constant, abates gradually and progressively; there are no oscillations of the current; the quantity obtained during one minute is equal or inferior, without recurrence, to that obtained during the preceding minute. Œdema, although it does contribute to lessening the rapidity of the current, is equally, with the idea of capillary embola, incapable of explaining the oscillations observed. The changes undergone by the blood after its passage through excised organs, *e.g.* muscle, lungs, &c., have already been studied by J. J. Müller, Ludwig, A. Schmidt, and Genersich. In experiments on excised lungs the author finds that, all other circumstances being equal, the rapidity of the blood-current traversing the lungs is proportional to the pressure exerted in the pulmonary artery. With the same pressure in the pulmonary artery the quantity of blood which traverses the lungs is much greater when they are dilated by the pleural cavity. With the same pressure in the pulmonary artery, the quantity of blood which flows through the lungs is much less when they are dilated by inflation through the trachea. The blood is attracted to the pulmonary vessels during inspiration.

Circulation in the Excised Liver. The author points out that the oscillations in the current are again found in the liver, where the vena portæ in its ultimate ramifications contains no muscular fibres, but only connective tissue and elastic fibres. The following, the results of Belz's experiments under Ludwig, on the circulation of a solution of gum in the liver, are then stated; and as they are not generally known they may be introduced here. Taking into view the diameter of the hepatic artery and that of the vena portæ, the portal circulation has a greater rapidity than the arterial hepatic one. The circulation in the hepatic artery is facilitated by the absence of a current in the portal vein; it is interfered with by a simultaneous current. The retention of bile in the biliary canals is a serious obstacle to the circulation of blood in the portal vein. If two different pressures succeed each other, the current varies, not only with the pressure under which it penetrates, but also with that which precedes it. If at the beginning of a current the pressure be constant, the quantity of fluid which passes through the liver is at first variable, and it is only after about ten minutes that equal quantities are received from minute to minute. With the same pressure in the vena portæ the rapidity diminishes proportionally to the pressure exercised on the surface of the liver. The immense importance of these observations, both clinically and practically, is at once obvious.

Influence of Toxic Agents on the Blood-current in Artificial Circulation.—If a few drops of an alkaloid be added to defibrinated blood, the current of blood which passes through the organ is immediately modified. Thus, nicotin added to defibrinated blood, circulating through excised lungs, greatly increases (to three times) the rapidity of the current. As soon as normal blood is admitted, the action of the alkaloid is effaced, the slowing of the rapidity (as expressed by the quantity which flows out from the pulmonary vein in a given time) which succeeds the toxic action is regular as in a dead organ; it shews no oscillations, yet a new dose of the alkaloid produces again an acceleration. The modifications in the rapidity are proportional to the dose of nicotin employed; the larger the dose, the greater the rapidity. Nicotin has, therefore, a special action, entirely opposite to that of cyanide of potassium, which causes arrest of the circulation by œdema. Exactly the same is true of the liver. In thus experimenting on excised organs we eliminate all effects of the central nervous system, to whose influence too many phenomena in the physiology of the circulation are too apt to be ascribed. Nicotin when added to blood produces a change in its colour and constitution; but this is not the cause of the action, for large doses of nicotin added to blood passed through dead organs had no influence whatever on the rapidity of the current. By the aid of Poisseule's formula, it is shewn that there are modifications in the calibre of capillaries under the influence of certain toxic substances, but whether due to contractility proper or not, the author leaves undecided.—[*Lond. Med. Recd.*, No. 115, 1875.]

Influence of the Brain on the Blood-Pressure in the Pulmonary Artery.—Badaud (*Verhandl. d. phys. Medicinisch. Gesellsch. zu Würzburg*, VIII. 1) has investigated this subject in Fick's laboratory. The blood-pressure was not measured directly in the pulmonary artery itself, but was estimated from the pressure in the right ventricle, the pressure during the cardiac systole being the same in the right ventricle as in the pulmonary artery. The thorax was not opened, but a catheter was passed through the jugular vein into the right ventricle, the catheter being connected with a new manometer devised by O. Fick. The pressure in the pulmonary artery is very much less than in the aorta, *e.g.* in the former 48 mm. Hg., in the latter 102. On division of the spinal cord the pressure sinks in both, but so much more in the aorta than in the pulmonary artery, that it becomes almost exactly the same in both, *e.g.* 18 mm. Hg. in the pulmonary artery, 20 in the aorta. Stimulation of the divided spinal cord causes a marked rise in the pressure as well in the pulmonary artery as in the aorta, though the rise is much greater in proportion to the normal pressure, in the pulmonary artery, than in the aorta. Stimulation of the splanchnics raises the pressure in the pulmonary artery very slightly. Compression of the aorta did not raise it at all.

Action of Lobelina on the Circulation.—J. Ott (*Boston Med. and Surg. Journal*, Jan. 1875) working in Bowditch's laboratory, experimented chiefly on rabbits. Lobelina in small doses increases the blood-pressure by acting as an excitant on the peripheral vaso-motor system. It seems to be mainly a respiratory poison, and in the cat it greatly reduces the temperature.

On the Iron in the System. Picard (*Comptes rendus*, Nov. 30, 1874) investigated this subject in Cl. Bernard's laboratory. The animals operated on were chiefly dogs. The dogs got no food on the day of the analysis, and the analysis was made on defibrinated blood. In 100 cc. of blood the following quantities of iron were found. Young, very fat dog 0·092; adult dog 0·065; dog weakened by previous bleedings 0·041. These are the extremes. As to the meaning of these variations, the author compared the quantity of iron in 100 cc. of blood with the quantity of O, which 100 cc. saturated with this gas, liberated in vacuo. This table shews that the two quantities vary in a parallel manner, and that their relation is sensibly constant and equal to 2·3. He finds further that the spleen under ordinary circumstances contains a much higher percentage of iron than is to be found in the blood, *e.g.* in spleen, dog 0·24; ox 0·15; cat 0·34. The liver comes next, but the proportion never exceeds that in the blood, and is rarely equal to it.

On the Rôle of Gases in the Coagulation of the Blood.—E. Mathieu and V. Urbain (*Comptes rendus*, LXXIX. 1874, 665, Absts. in *Centralblatt*, No. 60). (*Jour. of Anat. and Phys.* VIII. 408, for results of previous experiments) proceed from the view that fibrin is dissolved pre-formed in the blood, and is simply excreted on coagulation taking place. The cause of this coagulation they see in the union of fibrin with CO_2. If two portions of blood are caught directly from the artery in the receiver of the air-pump, and their gases removed before and after coagulation, then more CO_2 is obtained in the former case. 100 vols. of blood gave

Before coagulation.	After coagulation.
48·05 ccm. CO_2	39·38
50·00 " "	44·85
49·00 " "	40·95
54·40 " "	42·50

Blood deprived of CO_2 does not coagulate, but the excretion of coagula occurs at once when a current of CO_2 is passed through it. The authors prepare blood free of CO_2 by adding a few drops of NH_3 to prevent coagulation, and then displace the O by CO, and lastly remove the CO_2 and NH_3 by pumping. Such blood does not by itself coagulate, but does so on CO_2 being passed through it. The authors observe further, that some venous blood coagulates with difficulty, *e.g.* renal venous blood. According to the authors, this blood contains little CO_2, the urine, on the contrary, an obvious amount; they refer this phenomenon to the diffusion of CO_2. Proceeding from this observation the authors made fast a piece of moist intestine to a divided artery. The blood therein remained fluid, when it was kept in motion (in the other case CO_2 increases in quantity which causes coagulation). Venous blood contains more NH_3 than arterial, and therefore coagulates more slowly. 100 ccm. venous blood from the dog gave 15,85 ccm. NH_3, 100 ccm. arterial 10,62 (?). The fibrin obtained by beating the blood, on being heated with acids, and on being pumped out, yielded [10 grms. dried fibrin (= 60 moist)] 80—90 ccm. CO_2.

PLOSZ AND GYORGYAI ON COAGULATION OF BLOOD IN THE LIVING ANIMAL.—Plosz and Gyorgyai (*Archiv für exper. Path. und Pharmak.*, Band ii. 1874) confirm the assertion of Naunyn, that injection of lake-coloured blood into the veins of a rabbit is followed in most cases by death, through thrombosis of the right heart and pulmonary artery. Of fourteen rabbits only two survived the injection. In every case where death resulted thrombosis was proved to be the cause of death. Outside the body the addition of lake-coloured blood to normal blood greatly accelerates coagulation. The second part of the paper is occupied with the question of the injection of foreign blood. Fourteen rabbits received varying quantities of defibrinated blood from hens and turkeys; only one of these survived, two were killed intentionally, eleven died in consequence of the injection, some of these on the sixth day after the injection. As to the cause of death, in three cases extensive thrombosis in the right heart, in the large veins of the right heart, and in the pulmonary artery, were found; in five cases the section was not made early enough to determine whether the thrombosis took place *intra vitam* or not; in three cases the presence of thrombi was distinctly ascertained, so that to the blood as such a poisonous action is to be ascribed. [*Vide* the experiments of Creite, who asserted the poisonous action of the serum of the blood of the bird in the rabbit.] The blood-corpuscles of the bird could be discovered several hours after the injection, but they gradually broke down, in that the stroma became discoloured, and the nuclei became free. [*Vide* the results of the experiments of Landois, *Journ. of Anat. and Phys.* VIII. 405.] Blood-colouring matter appeared in the urine. In the frog the solution of the foreign blood-corpuscles occurs much quicker than in the rabbit. [See also the results of W. Müller's, where no thrombosis was observed after the injection into the veins of dogs of very large quantities of defibrinated dog's blood. *Journ. of Anat. and Phys.* IX. 222.]

ZIEGLER ON THE EXPERIMENTAL PRODUCTION OF GIANT-CELLS FROM COLOURLESS BLOOD-CORPUSCLES.—Ernest Ziegler (*Centralblatt für die Medicinischen Wissenschaften,* Nos. 51 and 58, 1874,) cut from mirror-glass, small glass plates of different sizes, partly quadratic, partly long rectangular, ground off the edges carefully, and affixed to each with porcelain glue a fine cover-glass of the same size, so that there remained between the glass lamellæ an empty capillary space, accessible from all sides, with the exception of the corners. These plates were brought under the skin and periosteum of dogs and rabbits, or were introduced into one or other of the large cavities of the body. This was done under the impression that the colourless blood-corpuscles would penetrate into all the spaces, would wander under the cover-glass, and there, independent of the organism, be nourished by lymphatic fluid, and undergo this or that metamorphosis. The author met with many failures, and recommends the following method. Small plates of glass must be used 10 to 20 millimètres (0·04 to 0·08 inch) long, and 10 millimètres (0·4 inch) broad. Large ones easily occasion profuse suppuration. The plates were generally left from ten to twenty-five days in the spot operated on. The best field for operating is the inner side of the thigh of not too old dogs. Rabbits gave no satisfactory results. After the plates were removed they were slightly washed, and at once placed in a 1 per cent. solution of perosmic acid, and allowed to remain there for two days. They were then placed in spirit with glycerine, then in pure glycerine. The following were the results of sixty-five experiments. An inwandering of colourless blood-corpuscles took place in all cases. The changes of the same in the first ten days varied according to the direction of the development. After several days a flattening of the corpuscles and the formation of a cellular mosaic was often to be observed. After this time the author found the following—up to the twenty-fifth day. In the greater number of cases only retrogressive changes were observed. The progressive processes shewed the different developmental directions.

1. *The formation of a Reticular Tissue with Enclosed Epithelioid Cells and Rich Development of Giant-Cells.*—This is, without doubt, the most interesting result. The giant-cells consist of finely granular protoplasm and certain numerous large oval nuclei and distinct nucleoli, sometimes with round sharp contours, at others provided with processes. They lie in the above-mentioned reticular tissue, surrounded by cells which in their immediate neighbourhood are of considerable size, but diminish towards the periphery. The size of the giant-cells is very various, and it can be seen, on one and the same microscopical preparation, how they are developed from the colourless blood-corpuscles by increase of the protoplasm and simultaneous increase of the nucleus, till they reach the dimensions of the largest known giant-cells. In preparations in which giant-cells were present the author never observed the development of blood-vessels.

2. *Development of Connective Tissue and Vessels.*—Similar appearances to those of developing connective tissue were found. The preparations incline the author to lean to the paracellular origin of the reticular tissue. As the first stage in the development of the vessels there is clearly observed a network of peculiarly changed colourless blood-corpuscles ranged one on another, which increase considerably

on the surface, and are firmly fixed on the edges, and gradually assume an endothelial character. In addition to this so-called secondary formation of vessels, the author observed at a later date bud-like formations from the wall of existing vessels. Still even here the auther thinks that these bud-like formations are formed by the apposition of neighbouring lymph-corpuscles. The author draws the following conclusions :—1. Real giant-cells can develope from colourless corpuscles. 2. Under similar conditions cytogenous connective tissue with epithelioid cells are formed. 3. These formations are to be placed equal to certain forms of tubercle; or, in other words, tubercle with its giant-cells is an inflammation focus in which the colourless corpuscles heaped up at any spot (probably intracanalicular —Rindfleisch, Schüppel) undergo a development. This, according to the author, is caused by imperfect nutrition of the cells, in so far as this is not sufficient to form a new connective tissue. According to this view giant-cells are to be regarded as imperfect new cell-formations. 4. The formation of intercellular substance in reticular tissue is paracellular, arising anew by a cutting off from the sides of the cells.

Purves on the Place where the White Blood-Corpuscles wander out of the Vessels.—L. Purves (*Onderzoekingen gedaan in het Physiol. Labor., Utrecht*, 1873, III.), to investigate the place where the white blood-corpuscles pass through the wall of the vessel in Cohnheim's inflammation experiment, injected a solution of silver into the vessels of a frog prepared after the manner of Cohnheim. The colourless corpuscles, without exception, wander out between the boundaries of the endothelial cells. They never pass through the substance or through the nucleus of an endothelial cell. According to the author the red corpuscles only pass out by those channels which have been previously made for them by the colourless corpuscles. The author found no stomata of any kind on the epithelium of the vessels.

On the Influence of the Concentration of the Blood and Tissue-Juices on the Changes of Form and Place of the Colourless Blood-Corpuscles.—R. Thoma (*Virchow's Archiv*, Vol. LXXI. Heft 1), on this subject :—

1. *Influence of the Concentration of the Surrounding Fluid on the Amœboid Movements of the Colourless Blood-Corpuscles removed from the Body.*—Blood of the frog, placed in the gas-chamber, and from which water was removed by the passage through it of a stream of air, shewed, that in the portion of blood poor in water, the number of round motionless colourless corpuscles surpassed considerably the number of those shewing changes of form. In blood in which the quantity of water was increased, the greater number of the colourless corpuscles shewed the branched forms, such as are produced by the flowing movement of protoplasm. Those corpuscles which adhere to the cover-glass are more spread out, shew clearly three or four nuclei, and bear more richly branched processes, contain oftener vacuoles, and shew more lively changes of form than those floating

free in the fluid. This is, without doubt, due to the action of the surface, and produced by strong adhesion of the body of the cell to the surface of the glass. This property also belongs to a series of other solid bodies, and also to the intima of the vessels. The white blood-corpuscles become more sluggish in their changes of form with the increase of the concentration of the fluid, and the greater number change into rounded cells, which sometimes have fine processes on their surface. This is not due to death of the corpuscles, for by increase in the quantity of water they again became lively in their movements, and resume the properties of freshly drawn white-blood-corpuscles. These observations were made in the blood of *Rana temporaria* and *esculenta;* but the same is also true for that of *Salamandra maculosa,* and *Triton cristatus,* and also for that of warm-blooded animals; at least for the guinea-pig and dog. Under the influence of water the contents of the white corpuscles may be increased four times, and this can only be regarded as an imbibition phenomenon. 2. *Experiments on Colourless Corpuscles circulating in the Blood*, produced by injection of water into the circulation of the frog.—Besides unchanged colourless corpuscles there are a large number which shew forms such as can be produced upon blood under the influence of water outside the body. Those which lie upon the walls of the vessels exhibit very lively changes of form. In an opposite experiment frogs were exposed for several days to evaporation. Microscopic observation shewed that under these conditions in the tongue, no amœboid movements were to be observed in the corpuscles circulating in the blood, and also in those touching the walls of the vessels, and the injection of a 3 per cent. solution of common salt into the veins shewed that increase of the quantity of salts acted quite in a similar manner to the regular concentration of the blood by evaporation of water from the surface of the skin. 3. *Experiments on the Wandering Cells in Living Tissues.*—The question was whether colourless corpuscles which have wandered outside the vessels are influenced in a similar manner by differences in concentration of the tissue fluids. The cells which have wandered out into the tissue shew the lively amœboid changes of form and place, whilst by infusion of a 3 per cent. salt solution and evaporation from the skin, the amœboid movements of the wandering cells become slower and very soon cease altogether. The same is observed with a 1·5 per cent solution, the colourless corpuscles becoming round and shining, and changes of place could no longer be observed of them; whilst with a 0·5 per cent. solution the changes both of form and place were very lively. Irrigation of the frog's tongue with various strengths of salt solution also produced important changes in the calibre of the blood-vessels, and therefore in the rapidity of the blood-current. Under irrigation by a 0·5 per cent. solution, a very plentiful out-wandering, specially from the small veins, takes place, while in the same organ with a 1·5 per cent. solution, the wandering-out of the colourless corpuscles is completely suppressed. This solution acts first on the blood-vessels, producing a pronounced dilatation of the arteries, and therewith an acceleration of the blood-current in the arteries, capillaries and veins, as Wharton Jones had already proved, and which H. Weber, F. Schuler, Buchheim, Vierordt, etc. shewed, depends essentially on the diffusion of the blood-plasma with the salt solution. The acceleration of the blood-current is so considerable that the venous current takes on part of the characteristics of the arterial one. Specially, the marginal position of the colourless corpuscles disappears. The second effect of the 1·5 per cent. solution of chloride and common salt is its influence on the changes of form and place of the colourless corpuscles. The chief results of this investigation are, first, that changes in the quantity of the salts and the concentration of the blood and tissue-juices, within those limits which are compatible with the existence of the animal organism, exercise a powerful directing influence on the changes of form and place of the colourless corpuscles. Concentration of the tissue-juices causes these corpuscles to lose their property of changing their form and place, so that they become round and shining. These phenomena may last for days, until a dilution of the tissue-juice is again produced, when the lively changes of form and place of the corpuscles begin again. Thus they shew a tolerably wide similarity with vegetable protoplasm, as pointed out by Kühne on the myxomycetæ. Secondly, it is proved that the wandering-out of colourless corpuscles from the vessels of the frog's tongue, in spite of a large loss of substance, can be completely hindered by the irrigation of the wound with a 1·5 per cent. solution of common salt, that it is hindered by the thickening and increase of the salts of the blood. By irrigation with salt solution, of the above concentration, the action depends upon the acceleration of the rapidity of the current caused by the continuing dilatation of the arteries, and of the direct influence upon the protoplasm of the colourless corpuscles of the blood. The acceleration of the venous current prevents the marginal position of the colourless corpuscles, and in this way extinguishes the first condition for the out-wandering of the same from the veins. The influence of a 1·5 per cent. solution of common salt stops, during the irrigation, change of form of the protoplasm of the colourless corpuscles, and simultaneously their out-wandering from the vessels, and every obvious change of place in the tissues.

Respiratory Systems.

"Influence of Food on the consumption of oxygen and the excretion of CO_2 in Man." C. Speck, *Arch. f. exp. Path. u. Pharmak.* 1874, II. 405 (Absts. in *Centralblatt*, No. 9, 1875).——"Paralysis of the Diaphragm after section of the phrenic nerves." Alyschewsky, *Berlin Klin. Wochenschr.* No. 35 (Abstract in *Lond. Med. Recd.*, No. 97, 1874).——"On the absorption of CO_2 by solutions of neutral phosphate of soda." T. Setschenow, *Centralblatt*, No. 3, 1875.

Alimentation.

"Phenomena of Deglutition as studied by the graphic method." Arloing, *Comptes rendus*, Nov. 2nd, 1874 (Absts. in *Lond. Med.*

Recd., No. 99).——"On the intestinal Juice." Dr Leven, *La France Médicale*, Oct. 21st, 1874.——"On the Physiology of Vomiting and the action of anti-emetics and emetics." T. Lauder Brunton, *Practitioner*, Dec. 1874.——"Pepsine in commerce." C. Symes, *Lond. Med. Recd.*, No. 108.——"Estimation of the nitrogen of albuminates." W. Kreussler, *Zeitsch. für Anal. Chem.* XII. 354, and J. Seegen and J. Nowak, *Pflüger's Arch.* 1874, IX. 227.——"On Fermentation in the Stomach and the formation of gastric gases which burn with a yellow flame." A. Ewald, *Reich. und du Bois' Arch.* 1874, 217 (Absts. in *Centralblatt*, No. 6, 1875).——"On the acid of the Stomach," Ralfe, *Lancet*, 1874, July 4; R. Maly, *Annal. de Chem. u. Pharm.*, Bd. 173, 227; and Laborde, *Gaz. Méd. de Paris*, Nos. 32, 33, 34 (Abstract of all three papers in *Centralblatt*, No. 12, 1875).

ON THE GASES PRODUCED DURING ARTIFICIAL PANCREATIC DIGESTION. Kunkel (*Verhandl. d. Phys.-Math. Gesellsch. zu Würzburg*, VIII.) arrived at the following results:—1. In artificial pancreatic digestion of pure fibrin by means of the pancreatic fluid, CO_2, H, hydro-sulphuric acid, N, and CH_4 appear, and traces of other hydro-carboids. 2. The proportion of CO_2 increases, and that of H. diminishes with the duration of the experiment. 3. Hydro-sulphuric and marsh-gas only appear towards the end of the experiment. 4. Nitrogen is present in small quantity. It is not due to admixture of atmospheric air. 5. Oxygen was never to be found. Also G. Hüfner, *Journ. f. Pract. Chem.* N. F. x. 1874. i.

FORMATION OF ASPARTIC ACID DURING PANCREATIC DIGESTION.—S. Radziejwski and Salkowski, *Ber. d. deutsch. Gesellsch.* 1874, VII. 1050. The authors confirm the supposition that aspartic acid is formed when the pancreas ferment acts upon albumen (blood-fibrin).

HEIDENHAIN ON THE SALIVARY GLAND.—R. Heidenhain (*Pflüger's Archiv*, Vol. IX., and Abstract in *Centralblatt für die Medicin. Wissenschaften*, No. 1, 1875) says that Rossbach questioned the antagonistic action between atropin and physostigmin in relation to the secretory fibres of the chorda tympani, as asserted by Heidenhain. To establish his results the author atropinised curarised dogs by injection into the blood, until stimulation of both chordæ no longer produced secretion, ligatured both subclavian arteries to control the circulation in the submaxillary glands, and injected a solution of physostigmin under previous occlusion of the carotid into the branch of submental artery going to the hilus of the gland. The immediate consequence was that on the side where physostigmin was employed, the chorda became again excitable, whilst stimulation of the other chorda gave no result, when, in order to make the conditions of the experiment alike in the two glands, a solution of an indifferent salt was injected into the artery of the other gland. Gianuzzi shewed, in 1865, that when the salivary secretion was arrested by the injection of dilute acid or solution of soda into the excretory duct, stimulation of the chorda produced a very considerable œdema, and he concluded from this that the secretion normally consists of two acts, of the increased transudation of lymph by paralysis of the vessels, and of the formation of saliva from this material by stimulation of the secretory nerves. The author shews that this hypothesis is untenable, in that after the injection of atropin into the gland stimulation of the chorda caused acceleration of the blood-current, but never pronounced œdematous swelling. The latter is also absent on injecting an indifferent fluid into the excretory duct after atropinising, but occurs at once when a dilute acid or soda solution is used instead of the indifferent fluid. The author suggests that the œdema arises from diffusion, caused by the differences of the blood-fluids and the injected acid or soda solution bathing the vessels.

Zweifel on the Digestive Apparatus of Newly-born Children.—Zweifel, in a series of researches "On the Digestive Apparatus of Newly-born Children" (pamphlet, Berlin, 1874, pp. 47, Abstract in *Centralblatt für die Medicin. Wissenschaften*, No. 59, 1874), carefully investigated the bodies of newly-born children, or those a few weeks old.

Salivary Glands.—Parotid and submaxillary glands were extracted, either simply with water or after Wittich's method. The parotid extract always changed starch rapidly into sugar, as was proved by Trommer's and the fermentation tests, and by the polariscope. All experiments with extract of the submaxillary, on the contrary, gave only negative results,—a very striking phenomenon in relation to the condition of these glands in the adult. The ordinary diseases of children (diarrhœa, vomiting, etc.) produced no essential change, only the fermentative action was less and slower. On the contrary, this action during the fœtal period appears to be absent till near to its termination.

Stomach.—The whole organ was finely chopped up, extracted with water and hydrochloric acid added to the filtrate to the extent of one per 1,000; in many cases also the glycerine extract of the stomach was used. As the test, well-washed fibrin and casein as free from fat as possible were employed. In all cases there was a tolerably large production of peptones, not far behind that produced by an adult stomach which was used as a control. On the contrary, in a fœtus of six months the results were negative. Casein proved specially digestible.

Pancreas.—The diastatic ferment is absent from an infusion of this gland till up to the end of the first month of life, as shewn by Korowin and corroborated by the author. It, however, possesses the property of converting albuminous bodies (casein and fibrin) into peptones, and of splitting up neutral fats. In two cases of diarrhœa it had also lost this property.

Glycogen was detected by Brücke's method in the liver of a four months' fœtus which was examined a few minutes after the heart had ceased to beat.

Biliary matters (colouring matter and acids) were found in the intestinal canal of a three months' fœtus.

Etzinger on the Digestibility of Gelatine-yielding Tissues.—J. Etzinger (*Zeitschrift für Biologie*, 1874, Band x., Abstract *in Centralblatt für die Medicinischen Wissenschaften*, No. 45, 1874) tested, on the one hand, the action of artificial gastric juice on the ligamentum nuchæ, tendon, cartilage and bone, and on the other, fed with the proper substances, a dog, whose excretion of nitrogen was diminished to a constant low value by being allowed to hunger for several days. The increase in the quantity of nitrogen after the supply of the above substances is taken as the standard for their utilisation in the body.

1. *Bones.*—Bone-powder, prepared by rasping the compact substance of ox-bones, dissolved tolerably richly in hydrochloric acid (0·3 per cent.). After ten days' digestion of 10 grammes (150 grains) of the powder, with in all 1,200 cubic centimètres (rather more than 40 ounces) of dilute acid, only 1·83 grammes remained undissolved. The residue was richer in organic substance than the original substance, organic substance, however, being plentiful in the solution. The dog experimented on shewed, after taking 150 grammes of bone, an increase in the excretion of urea of about 8 grammes per diem. An absorption of lime from the bones could not be proved; on the contrary, the quantity of this mineral in the urine shewed a diminution. The author supposes that the cause of this phenomenon lies in the diminished decomposition of the tissues of the body through the supply of gelatine. The phosphoric acid shewed a small increase. Corresponding to this the fæces evacuated during feeding with bones contained 308·5 grammes of ash, *i.e.* somewhat more than the supplied bones.

2. *Cartilage.*—Costal cartilage of a calf dissolved in not inconsiderable quantity in a 0·3 per cent. solution of hydrochloric acid (*e.g.* 24·3 per cent.), but much more on the addition of pepsin (74·9 per cent.). After feeding with cartilage, the fæces only contained traces thereof, the excretion of urea shewed an increase of about 11 grammes after feeding with 72·2 of dried cartilage (at 100° Cent.).

3. *Tendons* were affected little by the action of a 0·3 per cent. solution of hydrochloric acid. After eight days' digestion the amount dissolved in the pepsin mixture was 12·05 per cent.; on the contrary, after three days they were broken up and dissolved, and 94 per cent. had gone into solution. The solution did not form a jelly after neutralisation and evaporation. The ligamentum nuchæ of an ox conducted itself similarly; on digestion for ten days it disappeared completely, only an unimportant residue remaining. The dog, after hungering for several days, received in one day 367·1 grammes of tendon, on the next 360·3 grammes, corresponding to 245·8 grammes of the dried substance. In the fæces only a very minute quantity of tendon could be proved. The excretion of nitrogen in the urine rose to 21·2 grammes (the tendon contained 46·4 grammes). All gelatine-yielding tissues are therefore capable of digestion and utilisation; most extensively tendon, then cartilage, and lastly bone, of which less organic substance is absorbed, probably on account of its rapid passage through the intestinal canal. The author confirms the results of

Frerichs and Kühne, that gelatine, by digestion with pepsin and hydrochloric acid, loses its property of gelatinising.

On the Significance of Gelatine-yielding Tissues for Nutrition.—C. Voit, *Zeitsch. für Biolog.* x. 202 (Abstract in *Centralblatt*, No. 13, 1875) has extended his observations upon this subject by employing gelatine-yielding tissues instead of gelatine. As such, he used the cartilage of bones prepared by boiling with HCl. The dog hungered at first for 5 days, the excretion of urea was thereby reduced to 10 grms. On the three following days it obtained 1032,3, 1076,9, 1136,5 grms. moist cartilage, and each time 50 grms. fat, and then followed three hunger days. Urine and fæces were analysed throughout the whole time of the experiment. In all 1071,4 grms. dried osseine with 169,6 grms. N. were introduced; on the three feeding days 159,58 grms. N. were excreted, still the action of the osseine continued over the two following days. The whole quantity of N. arising from the osseine was 185,2 grms. To this is to be added the excretion of N. per anum on the same days = 9,68 grms., in all therefore 194,9 grms. N. excreted, against 169,6 grms. introduced; per diem 8,4 N. in opposition to 10,17 grms. during hunger. Of sulphuric acid, in urine and fæces together, 10,43 grms. were excreted, whilst the osseine introduced contained 11,14. This coincidence shews, that osseine, and not albuminous substance, is decomposed in the body, for this should have given 47,8 grms. H_2SO_4 in the urine and fæces. As osseine contains still less phosphoric acid, the quantity of phosphoric acid in the urine also increases. It is therefore proved that the gelatine-yielding tissue acts as directly in the body as gelatine itself, only that it is better tolerated in larger quantity by the intestine. No matter how one may increase the quantity of osseine, more N. always appears in the excreta than is contained in the osseine introduced, consequently always more albumen is given off from the body, whilst in feeding with albumen a limit is very soon reached by which the income and expenditure are equally great. One is not able to construct a diet for the animal organism out of osseine, fat, salts and water; the albumen cannot be dispensed with, it is necessary for the new formation of cells. The author then replies to the attacks of Hoppe Seyler upon "organ albumen" and "circulating albumen," and against the view (of Voit) that the greater part of the albumen supplied is decomposed without previously becoming tissue constituents (*Jour. of Anat. and Phys.* VIII. 206). Liebig supposed that a previously organised albumen in the animal body was decomposed with the production of work, and that the albumen of the food only served to build up the destroyed organs. It was however found that large quantities of albumen were very rapidly excreted as urea; it was assumed that they were directly burned in the blood, and this process was named "*Luxus-consumption.*" The author had in conjunction with Bischoff partly proved that this excess of albumen increased the albumen in the organism; that it is not a "luxus," and chiefly on this ground denied the luxus consumption. 2. It is quite another question, however, in what part of the body the destruction of albumen does take place, and whether thereby only organised or non-organised albumen is decomposed. The author is of the opinion that the albumen contained in and circulating with the nutrient fluids is chiefly decomposed "circulating albumen." The organ albumen is as a rule not used, but it can however under circumstances, as by hunger, be employed. 3. When the decomposition of albumen increases with rich supply of albumen, this effect arises by the absorbed albumen reaching the place where favourable conditions for its decomposition are present—an exchange with the organ. The author regards the cells as the chief place of this decomposition. 4. According to V. the albumen of the food in contact with the living tissues decomposes, without itself having become more organised; according to Hoppe Seyler, on the contrary, the cells and tissues are continually in a state of decomposition and reconstruction, and the extent of the transformation is governed by the quantity of albumen supplied. Voit is therefore of the opinion that a destruction of the organised form of albumen only occurs exceptionally, and that as a general rule the destruction of albumen imbibed by the tissues and organs takes place under the influence of the cells.

Liver.

ASP ON THE ANATOMY AND PHYSIOLOGY OF THE LIVER.—G. Asp (Ludwig's *Arbeiten*, Vol. VIII.), in his experiments on the secretion of bile, was led to make a histological examination of the liver of the rabbit, to ascertain why and how fluids excreted from the blood were divided between the lymphatics and bile-ducts. The paper is divided into a histological and a physiological part. Although it is well known that the nucleus of the hepatic cells is often double, still it is not a necessary part of these cells, and although, as is generally the case, it is present, it has not always the same appearance. The author has found that the nucleus may be absent from the hepatic cells, and has treated such a liver by all the methods at present known to histologists for this purpose, but has not been able to render a nucleus visible. This condition does not depend upon food having been previously withheld from the rabbit. Even in a piece of such a liver, which was placed for a long time in often changed 10 per cent. solution of common salt, no nucleus was observed. (The 10 per cent. solution of common salt is a very valuable isolating medium.) The author also insists on the facility with which the hepatic cells are altered by pressure. Even under 50 mm. Hg. for injecting the portal vein, these cells assume the most varied and singular shapes. With regard to the structure of the walls of the smaller bile-ducts, the authors find that as long as the cylindrical epithelium is present, several layers of a striped tissue are visible between, by which, at regular intervals, numerous fusiform bodies are enclosed. The stripes and long axes of the spindles lie in the long axis of the ducts. These stripes disappear completely on boiling fine sections of the interlobular tissue in hydrochloric acid and alcohol (1 in 1000). They thus conduct themselves differently from the middle layer of the small arteries, which is not affected by boiling in the alcohol and hydrochloric acid mixture. This fact supports the view that the stripes are composed of several layers of collagenous fibrillæ. The spindles have the appearance of nuclei. According to this view the tissue surrounding the epithelium of the fine bile-ducts would belong to the layers of connective tissue (*Bindegewebshäuten*) which consist of fibrils and cells, so that the muscles which Heidenhain ascribes to these ducts would be absent. Even if muscles are present they can only lie in the long axis of the ducts, for the spindle-shaped nuclei always run parallel to the duct. Asp recommends the injection of a 0·5 per cent. solution of chloride of palladium into the ductus comm. choledochus, in order to obtain good preparations of the bile-ducts. The tissue is then placed for eight days in a concentrated solution of bichromate of potash. The cells are then easily brushed away, and the remaining stiff framework consists essentially of the interlobular tissue. The bile-ducts in penetrating into the lobule lose at the same time their cylindrical epithelium and their striated investment, their walls being composed only of fusiform nucleated plates disposed in spirals. E. H. Weber has already shewn that a solution of alkannine in turpentine penetrates into the interior of the cells; and the author has satisfied himself, by the injections of gutta percha dissolved in alcohol, and afterwards by the non-passage of a watery solution of Berlin blue into the cells, that there is no rupture of the cells produced by the injections, and that therefore this passage of alkannine and gutta percha into these cells must take place by filtration. MacGillavry, as is known, injected intralobular perivascular spaces, both by injection of the lymphatics in the liver of a dog, and also by the 'puncture' (*Einstich*) method. Frey and Irminger confirmed the existence of these spaces for the liver of the rabbit. E. Hering, however, denied that these spaces were the origin of the lymphatics, and did not succeed in injecting them in the liver of the rabbit. Asp has succeeded in injecting them in the rabbit, by forcing serum for a long time into the vena portæ, under a pressure of 30 to 50 mm. Hg. 2. Schmulewitsch, under Ludwig's direction, found that poisoning with curara slightly diminishes the secretion of bile. Asp corroborates this statement. From a series of experiments the author shews that a liver, from which the blood-current has been cut off for longer than ten minutes, can again form bile, when blood is admitted to it. If, however, blood is excluded for an hour or longer, then the secretion is only re-established in a very incomplete manner. The condition of the secretion of bile was tested in a liver when the rapidity of the blood was diminished below the normal; first, by ligature of one branch of the vena portæ, whilst the corresponding branch of the hepatic artery remained open; secondly, narrowing of the trunk of the vena portæ; and thirdly, section of the spinal cord. The first of these methods was already employed by Schmulewitsch, who shews that the quantity of blood carried by the hepatic artery is sufficient for keeping up the secretion of bile, but this secretion by no means necessitates the properties of arterial blood, for it is known that the fluid, flowing through the hepatic artery, loses its bright red colour before it passes into the hepatic lobules, into the first capillary system. Closure or narrowing of the vena portæ and section of the spinal cord diminished very materially the quantity of biliary matter secreted. All these three conditions then diminish the secretion of bile. The injection into the jugular vein of a curarised rabbit of several quantities (30 to 40 centimètres) of a 0·75 per cent. solution of chloride of sodium, heated to 38° C. (100·4° Fahr.), did not exercise any notable influence on the biliary secretion. The quantity of solids in the bile, however, after the injection of common salt solution, shewed a manifest diminution. These experiments, therefore, shew that the blood can undergo very considerable changes in its composition without losing its bile-forming property. The life of a rabbit could not be sustained by substitution of defibrinated dog's blood for its own blood. The cause of death the author ascribes to coagulations which were produced in the remainder of the rabbit's blood by the addition of that of the dog. The author then attempted to establish a circulation of blood in a liver which had been excised from the body. This is a field which is likely to yield many new results; and already Professor Heger, of Brussels, under Ludwig's direction, has performed similar experiments on the excised lungs (*Artificial Circulation in Excised Organs.* P. Heger: Brussels, 1873). The liver of a rabbit was taken and kept at a temperature of 38° C. in an apparatus constructed for the purpose (we must refer to the original for details), and as it was impossible to obtain the necessary amount of defibrinated rabbit's blood, the defibrinated blood of dogs, which had fasted for a considerable time, was employed and diluted with a solution of chloride of sodium, so that it could circulate in the vessels of the rabbit. This artificial circulation outside the body, and under as normal conditions as possible, was kept up for two to three hours, and a quantity of fluid, though a very small quantity, was obtained, which in all its properties, physiological and chemical, exactly resembled bile. The quantity obtained in the most favourable case was 0·5 centimètres, *i.e.* just as much as was obtained from the living liver in ten minutes with strong closure of the vena portæ. This bile is not derived from a store in the liver, for if only serum is employed (at a pressure of 30 millimètres of mercury), bile is only excreted at the commencement; soon it secretes none at all, and if the pressure is much elevated (50 millimètres of mercury), the fluid excreted has not the properties of bile.

Von Wittich on the Lymphatics of the Liver.—Von Wittich (*Centralblatt für die Medicinischen Wissenschaften*, No. 58, 1874), like Sikorski, has been able in the living rabbit to inject from the trachea an exceedingly but narrow-meshed network lying partly in the pleura, partly in the sub pleural tissue, and partly in the interstitial pulmonary tissue, and accompanying the blood-vessels; the author regards this network as consisting of lymphatics. In the freshly-killed animal he succeeded in injecting not only this network, but also the intercostal spaces, and even the external thoracic muscles when artificial respiration was performed. If a rabbit be killed by bleeding, and whilst artificial movement of the thorax is kept up, there is injected into the trachea, under moderate pressure, a concentrated solution of sulph-indigotate of soda, one is struck with the quantity of fluid employed, and with the fact that the whole animal becomes of an intense blue colour. The skin, the coverings of the eye, the tendons, the muscles, and the abdominal viscera, all become more or less blue, just as by injection into the blood. In only two places has Von Wittich been able to follow exactly the blue-coloured channels in the choroid and in the liver. In both organs the blood-vessels were almost completely empty, or only partially filled with blood. The blue colour of the choroid arises from a blue layer lying around the vessel (Morano's lymph-sheath of the choroidal vessels); in the liver a fine injected network surrounds the portal vein and the branches of the hepatic vein, from which exceedingly fine, delicate, blue injected processes penetrate into the hepatic lobules between the blood-capillaries and the hepatic cells. Strongly injected vessels, evident to the naked eye, pass from the hilus, run parallel to the large vessels and the bile-ducts, and surround these, their finer branches passing towards the branches of the portal vein; but the author observed no direct communication between these and the perivascular network. These vessels are not to be confounded with the blood or bile-capillaries, and Von Wittich can only recognise them as lymph-capillaries. Further particulars as to the method employed are promised.

Fleischl on the Lymph and the Lymphatics of the Liver.—E. Fleischl (*Ludwig's Arbeiten*) finds that if the lymphatics which proceed from the porta hepatis to the receptaculum chyli be exposed shortly after ligature of the ductus choledochus, it is observed that their usually colourless contents are tinged yellow. This formed the point of origin of the present investigation. The supposition that the yellow colour exhibited by the liver-lymph was due to the admixture of bile, was confirmed by experiment. A few drops of the fluid gave distinctly with nitric acid Gmelin's reaction for the colouring matter of the bile. To ascertain whether it also contained the bile-acids, for special reasons (to be seen in the original) the lymph was not collected directly from the liver, but on a large curarised dog the ductus choledochus was ligatured through a small wound in the linea alba, and then the wound was sewed up. The thoracic duct was then exposed in the neck, and a cannula placed in it. In a few hours a sufficient quantity (100 to 200 cubic centimèters) of lymph was obtained. In about five hours afterwards the dog was bled from both carotids. From this blood a completely clear serum was obtained by means of the centrifugal apparatus. The serum of the lymph was also separated from the fibrin clot which formed in it upon standing. The analyses shewed that the lymph contained a considerable quantity of the bile-acids, whilst the blood did not contain a trace of them. The bile, therefore, when its natural outlets are occluded, passes into the lymphatics of the liver, and thence exclusively through the thoracic duct into the blood. If, in addition to the bile-duct, the thoracic duct be also ligatured, the bile does not pass at all into the blood, or only its traces. The second part of the paper is devoted to the consideration, what anatomical arrangements in the liver favours the passage of the bile into the lymphatics. In this part of the paper many new methods for the study of the structure of the liver are described:

1. All injections of the bile-ducts were made on the liver of the rabbit, before rigor mortis set in, and the pressure under which it was done was measured exactly. Alkannin in turpentine was employed for the injection of the bile-ducts, and the red colouring matter, just like Berlin blue, passed into the lymphatics. A filtered solution of asphalt in chloroform offers many advantages over this mixture. For this mass, the pressure required is at least 30 mm. Hg. With this asphalt solution the author often succeeded in injecting from the bile-ducts, not only the trunks of the lymphatics which run with the vena portarum, but also the network which covers the diaphragm.

2. The author found that the lymph also leaves the liver by a channel other than those already known. In the connective tissue which binds together the strongest branches of the hepatic vein lie lymphatics, which empty their contents into those of the diaphragm.

3. The author then describes the connective tissue of the liver. For its preparations two methods were employed. A one per cent. solution of chloride of palladium was injected into the hepatic vein, and then the liver was hardened in bichromate of potash. The finest branches of the hepatic vein can then be easily isolated. The tissue forms a network composed of fibrillæ and enclosed cells; the meshes are about as long as they are broad. The smaller bundles of connective tissue cut the finer branches at right angles, so that the long axis of the meshes becomes increased. In the mesh-work of the larger fibres is a very fine network with exceedingly fine meshes. On this second network the hepatic cells sit fast. To obtain the very fine network which stretches from the adventitia of the vena hepatica, this vessel is washed out with a half per cent. solution of chloride of sodium, and then injected with a dilute solution of nitrate of silver. This preparation is treated similarly to the last, being first hardened, and then the hepatic cells are brushed away. The bile-ducts are then injected with a one per cent. solution of perosmic acid under a pressure of 20 to 25 millimètres of mercury. Afterwards a watery solution of Berlin blue may be thrown into the bile-ducts, and the whole liver hardened in bichromate of potash solution. The very fine network of exceedingly delicate connective tissue which is brought into view by this process, seems to be a means of keeping the hepatic cells *in situ*. Its relation to the blood-capillaries has not been definitely made out. From the perosmic acid preparations, the author believes that the bile-capillaries are by no means mere furrows between the hepatic cells, but are

independent structures with a proper wall. These bile-capillaries stand in no recognisable relation to the connective tissue.

Feltz and Ritter on the Influence of the Injection of Bile on the Organism.—V. Feltz and E. Ritter (*Comptes Rendus*, LXXVIII. 1874) injected fresh bile into the veins, and observed the following phenomena. 1. Tetaniform convulsions occurred, which were followed by coma, insensibility, and death from a large dose. 2. There was slight decrease of the pulse, and diminution of the bodily temperature by 1° or 2° Cent. 3. There were pronounced salivation, vomiting of biliary masses, bilious, sometimes blood diarrhœa. 4. The bloody shewed fat granules, increase of fat and cholesterin. The blood-corpuscles shewed a tendency to flow together. The quantity of oxygen was diminished, and that of carbonic acid increased. On shaking with oxygen the blood did not absorb so much of it as normal blood. 5. The quantity of urine was increased, and only with very large doses of bile did it contain albumen and bile-pigment; on the contrary, it contained regularly a substance which had many resemblances to indican. Only when the animal died rapidly was the urine blood-coloured from dissolved blood-colouring matter.

On the Formation of the Bile-Pigments.—Schiff had proved that the liver possesses the property of attracting from the blood absorbed bile-acids injected into the alimentary canal, and again of excreting them in the bile. The same property is possessed by the liver with relation to the bile-pigments. According to J. Fürst Tarchanoff (*Pflüger's Arch.* IX. 329, Abstract in *Centralblatt für die Medicin. Wissensch.* No. 2, 1875), the bile excreted in equal intervals of time from a permanent fistula shewed quite an enormous increase of bile-pigments, when a solution of hæmoglobin or water was injected into the blood of the animal (dog); on the contrary, a relative diminution in the fixed constituents. It can either be assumed that the liver forms and excretes a large quantity of bile-pigments from the increase supplied dissolved hæmoglobin, or that this transformation has already occurred in the blood, and that the liver, in virtue of an increased attractive property, had only extracted and excreted the colouring matter already present in large quantities in the blood. The latter view is favoured by the fact, that after injection of a solution of bilirubin the colouring matter of the excreted bile is correspondingly increased. So rapidly and completely does this elimination occur, that neither in the bladder nor in the urine obtained from a fistula of the ureter present at the same time, could the presence of bile-pigments be proved. A similar experiment had already been made by Feltz and Ritter (*Journal de l'Anatomie et de la Physiologie*, 1870, p. 315), who injected four grammes of bilirubin into the blood of a dog, whilst the author only injected 0·1 grammes. If it be remembered that bile-pigments can be formed in the blood outside of the liver, and further that the liver possesses a very pronounced property of absorbing and excreting bile-pigments, then the hypothesis that this pigment is formed outside the liver becomes very probable. The above experiments also shew why in hæmatogenous icterus a tinging of the tissue does not occur. As a symptom of this icterus, an abnormally strong colouration of the fæces is to be observed. Lastly, the author remarks that after the injection of large quantities of distilled water or weak solution of hæmoglobin, the urine of the bladder as well as the ureter shew Gmelin's reaction in nearly equal intensity, from which is shewn that the bladder does not possess the property of taking up and retaining bile-pigments in the urine.

On the Formation of Bile-Pigment from Hæmoglobin in the Animal Body.—J. F. Tarchanoff (*Pflüger's Arch.* ix. 53, 1874, Abs. in *Centralblatt*, No. 48). The cause of the differences in the results of Kühne and M. Hermann on the one hand, and Naunyn and Steiner (*Journ. of Anat. and Phys.* viii. 420) on the other, on the formation of bile-pigment in vessels from the hæmoglobin, the author thinks lies partly in the choice of the animal operated on. Hermann employed dogs exclusively, the two last-named authors, principally rabbits. Gmelin's reaction was used as the test for bile-pigment. The test was not done with the urine directly. The urine was treated with lime-water, and then CO_2 driven through it till the lime was saturated. The precipitate so obtained carried with it the greatest part of the bile-colouring matter; a part remained in solution, but this can be obtained on adding to the filtrate some phosphate of soda. The precipitate of lime was dissolved in acetic acid, and with this the reaction was proved. The arrangement of the experiment was the following. Chloroform having been administered, cannulæ were bound into the ureters of dogs, and these cannulæ were brought into connection with vessels. The urine collected (about 1½ hours) was specially tested for bile-pigments; 100 ccm. of a solution of hæmoglobin (saturated at 30°) were gradually injected in the jugular vein. The urine collected during the injection was strongly bloody; gradually the bloody colour diminished, and the urine collected at this time gave a very strong bile-pigment reaction. By special control experiments the author convinced himself that neither injection of water alone, nor sufficiently long-continued narcosis by chloroform alone, caused the urine to contain bile-pigments. A large secretion of bile-pigment by the urine cannot be expected, as the greater part is probably excreted by the bile. To test this supposition, the author made an experiment on a dog with a biliary fistula. From this dog, at intervals of half-an-hour, three portions of bile were collected, then 150 ccm. of the hæmoglobin solution was injected into the jugular vein, and four portions of bile collected at intervals of half-an-hour. Each portion was mixed with 30 cm. absolute alcohol, the quantity of bile-pigment estimated from the colour, and beyond this the bile-acids were estimated. A very considerable increase in the bile-pigment resulted, beginning at once after the injection from four to sixty-seven times. The secretion of bile has increased, but, apart from bile-pigment, this depends on increased excretion of water. The urine passed half-an-hour after the termination of the experiment contained neither hæmoglobin nor bile-pigment. The author is of the opinion that bile-pigment is secreted in the kidneys, but is again absorbed into the blood.——" Changes in the Liver after Artificial Occlusion of the Portal Vein." A. Solowieff, *Virch. Arch.* LXII. 195.

On the Rapid Preparation of Glyco-cholic Acid.—G. Hüfner (*Journ. of Pract. Chem.* N. F. x. 267). Fresh bile is placed in a tall glass and covered with ether, and strong HCl is then added (to 40 ccm. of bile, 2 ccm. HCl). A milkiness occurs, then the whole mass passes into crystalline glyco-cholic acid. Pour off the ether, shake the residue well with water, and extract with cold water. A single crystallization enables one to procure the acid colourless. The produce is rich. The washings contain the taurocholic acid and the other biliary constituents.

Bilirubin.—R. Maly (*Wiener Sitzungsb.*, 1874, Band LXX. 3 Abth., Abst. in *Centralblatt*, 1874).

1. *Analysis of an Ox-gall Stone.*—Almost one-third of the stone consisted of bilirubin. It contained in 100 parts soluble biliary matter, 18·09; etherial extract, 5·28; phosphate and bilirubin-lime, 1·41; bilirubin, 28·1: residue and loss, 47·13. The residue was olive-coloured, contained still some lime with bilirubin, earthy-looking stuffs, and inorganic salts. According to Maly, bilirubin has the formula $C_{16}H_{18}N_2O_4$; according to Städeler, $C_{16}H_{20}N_2O_5$. Maly has prepared biliverdin from perfectly pure, previously analysed bilirubin, and convinced himself of the correctness of his formula. A further proof of the correctness of Maly's formula lies in the following. When the formation of biliverdin from bilirubin occurs by the simple addition of oxygen, as Maly's formula expresses, then 100 parts bilirubin must give 105·6 parts of biliverdin. By adding the remaining dissolved portion, the author actually obtained from 100 parts of bilirubin, 104·3 of biliverdin, so that there is no doubt of the correctness of his formula.

Pink and Heidenhain on Diabetes Mellitus and the Formation of Glycogen in the Liver.—H. Pink (*Inaugural Dissertation*, Koningsberg, 1874; Abstract in *Centralblatt für die Med. Wissensch.*, No. 3, 1875) investigated how long a rabbit must hunger in order to be certain that the liver contains no glycogen; and in this way, by testing one part of the liver for glycogen, digesting the second with saliva, and then analysing the sugar contained therein, he found that five days were sufficient to remove every trace of glycogen. A solution of ordinary grape-sugar (two to three grammes) was injected into the vena meseraica of a rabbit which had hungered for five days, and the animals investigated in from half-an-hour to an hour and a half afterwards. The investigation of the liver was carried out in the same way as formerly, only the weight of the piece of liver in boiling water was estimated, and the sugar also estimated in the first portion. The quantity of glycogen was now estimated. In all cases glycogen was found in the first piece of liver, and only traces or little sugar; in the second piece plenty of sugar. In that the sugar in the second piece can only have been derived from glycogen, the experiments confirm the results of Schöffer, that sugar injected into the vena meseraica passes into glycogen. Made aware that the grape-sugar contained dextrin, the author repeated the experiments with pure sugar, and once with glycerine, and arrived at a completely different result, the first piece of liver contained no glycogen, the second not more sugar than the first. Afterwards the author injected pure sugar as well as glycerine into the stomach, and found a plentiful formation of glycogen. The author concludes that sugar as well as glycerine are changed in some way by the stomach, and their change into glycogen rendered more easy.——In the experiments of Heidenhain (*Inaugural Dissertation*, Königsberg, 1875; Abst. in *Centralblatt für die Med. Wissensch.*, No. 3, 1875), chemically pure grape-sugar was injected into the vena meseraica of hungered rabbits, to settle the question whether sugar actually passes into glycogen. The author investigated a piece of liver each time before the operation, or a few minutes after the injection; the second larger piece of liver after the animal had lived from twenty to forty-five minutes. As with Pink, the weight of the piece of liver was taken, and the glycogen estimated quantitatively, the result, with one exception, was at one time more, at another less increase in the glycogen. Thus far his results stand in direct contradiction to those of the former paper. Nevertheless, the quantities of glycogen were always relatively smaller in proportion to the quantity of sugar injected. This was four to nine grammes (61 to 138 grains); the glycogen obtained was only 0·05 to 0·156 grammes (0·2 to 2·34 grains). Schöpfer's view that the liver can change 0·12 grammes sugar into glycogen in a minute, cannot therefore in this form be correct. The small quantity of glycogen led the author, like Pink, to the assumption that sugar undergoes some kind of change in the stomach or intestine, which renders it more fit to be transformed into glycogen. To test this idea the author ligatured the pylorus of rabbits (*b*) and then injected sugar, intact animals serving as a control (*a*). In fact the quantity of glycogen became markedly less after ligature of the pylorus, the urine contained no sugar, whilst it generally contained sugar. The quantity of glycogen in *a* was 0·119, 0·636, 0·206; in *b*, 0·014, 0·015, 0·075, 0·099, 0·085 grammes.

Formation of Glycogen in the Liver.—Salomon (*Virchow's Arch.* lxi. Heft 3, Abst. in *Lond. Med. Rec.*, No. 98, 1874) contributes a long paper upon the above subject. The following are his conclusions:

1. The liver contains sugar during life.
2. Gelatine is a glycogen-former.
3. So is olive oil in a less degree.

4. Milk-sugar and grape-sugar are also glycogen-formers. Mannite is apparently not so.

5. The primary acetyl-derivative [Monacetyl saccharose = $C_{12}H_{21}(C_2H_3O)O_{11}$] of cane-sugar is decomposed in animal bodies into acetic acid and sugar; the former is probably burnt up, the latter acts in the ordinary way as a glycogen-former.——"QUANTITY OF GLYCOGEN IN THE LIVER OF NEWLY-BORN CHILDREN." G. Salomon (*Centralblatt*, No. 47, 1874) obtained the bodies of fœtuses where perforation or cephalotripsy had been performed. From the liver of one fœtus the author obtained 1·2 grms. of glycogen.——"Liver-Glycogen," v. Wittich, *Centralblatt*, No. 8, 1875.

Genito-Urinary System.

"Daily Excretion of Urine in health." Rabuteau, *Gazette Méd. de Paris*, Jan., 1875 (Abs. in *Lond. Med. Rec.*, No. 115).——"On the excretion of Nitrogen in the Urine." B. Power, *Dublin Jour. of Med. Science*, Feb., 1875.——"On a modification of Trommer's test for Sugar." G. B. Fowler, *Lond. Med. Recd.*, No. 111.——"On the urine-pigments." J. Reoch, *Jour. of Anat. and Phys.*, IX. 176.——"On the appearance of Acetone in Diabetes mellitus." F. Rupstein, *Centralblatt*, No. 55, 1874.——"On the Presence of the Bile-Acids in physiological Urine." Joh. Höne, Inaug. Dissert. Dorpat, 1873, pp. 72 (Abs. in *Centralblatt*, No. 55, 1874).——"Contributions to the Albumen in Urine." H. Obermüller, Inaug. Diss. Würz., 1873, 23 pp. (Abs. in *Centralblatt*, No. 8, 1875).——"Colouring matter of Urine from the indigo group." R. Niggeler, *Arch. f. exp. Path. u. Pharmak.*, III. 1874, 71.——"Colouring Matter of Urine." Bogomoloff, *Centralblatt*, No. 14, 1875.——"The early Stages of Urea." B. Küssner, Inaug. Diss., Königsberg, 1875 (Abs. in *Centralblatt*, No. 14, 1875).——"Estimation of Urea by interbromiate of soda." Schleich, *Jour. f. pract. Chem.*, N. F. x. 261.

EXCRETION OF UREA IN A HUNGERED DOG.—F. A. Falck, *Habilitationsschrift*, Marburg, pp. 22, 1874 (Abs. in *Centralblatt*, No. 45, 1874), withheld from a well-nourished bitch of 8,960 grms. weight, all solid and fluid food, and estimated every six hours, till the death of the animal, the quantity of urine removed by the catheter, its specific gravity, its colour, and the quantity of urea. The animal was weighed every six hours and the temperature taken. The author found that with continued inanition the body-weight gradually suffered less loss, that from the second hunger-day onwards the daily decrease in weight (reckoned as percentage of the body-weight) remained tolerably equal till death. The animal died when it had lost 48·08 p. c. of its weight. The urine had always an acid reaction, the colour was reddish yellow, and had a mean S. G. of 1051. During the first hunger-days the quantity of urea excreted sank considerably; afterwards it increased, so that for several days more urea was excreted than on the second hunger-day; first, during the last days of life, the quantity of urea excreted was small. The author explains this change thus, that at first the fat was preferably oxydised for the sustenance of the temperature necessary for life, and later the albuminous bodies. The final diminution in the excretion of urea corresponds in time with the diminution in the temperature. From this it appears that the quantity of fat in the body of organisms totally deprived of food, limits essentially the duration of life.

Presence of Bile-Pigments in the Urine.—L. Lewin (*Centralblatt*, No. 6, 1875) remarks that Gmelin's reaction sometimes fails when instituted in the ordinary way. In a case of icteric urine the author could not get satisfactory results either by Huppert's method or by the ordinary Gmelin's reaction, though by other signs it was very probable that the urine contained a large amount of bile-pigment. The urine was allowed to stand in ice for twenty-four hours, when a deposit, intensely reddish-brown in colour, separated out, which proved to be uric acid salts. On applying Gmelin's test to a solution obtained by gently warming the sediment, the characteristic reaction was at once obtained. The filtrate did not give the reaction. The bile-pigment was in this case united either mechanically or chemically to the urate. The author therefore recommends the precipitation of the uric acid salts by the action of cold, and then to institute Gmelin's test with the dissolved sediment.

"Experimental Studies on Diabetes."—C. Bock and F. A. Hoffmann (Berlin. *Oliven*, 1874, 8vo. pp. 70) communicate the results of their experiments on the *normal quantity of sugar in blood of rabbits.* Well-nourished animals simply tied down always shewed, in their blood taken from the heart or from the artery, from 0·07 to 0·11 per cent. of sugar, which was estimated by Fehling's solution. Only when artificial respiration was kept up by pressure on the abdomen (on the liver) did the quantity rise in the cardiac blood to 0·2 per cent. By an ingenious experiment the authors shew that the sugar found arises from the liver and from the lymph of the intestinal canal. From other experiments it is very probable that glycosuria depends upon increased activity of the liver. After puncture of the fourth ventricle the quantity of sugar in the blood rose abnormally high during the first hour (to 0·29 p. c.) If in the second hour, where already sugar was distinctly found in the urine, the liver was excluded, in six out of eight experiments the diminution of sugar was quite apparent, and the increase of sugar after the puncture is not to be ascribed to diminished destruction of sugar in the organism, but to a greater supply in the blood, probably arising from the liver.——"Formation of Sugar in the fœtus and adult." Morrigia, *Reale Accademia d. Lincei, Estr. d. sess.*, III., 9th Feb., 1873 (Abs. of both papers in *Centralblatt*, No. 10, 1875).

"Simple Preparation of Urinary Pigment from Hæmoglobin." F. Hoppe-Seyler (*Ber. d. deutsch. chem. Gesellsch.*, III. 1065) formerly observed that on heating hæmatin in alcoholic solution with tin and HCl, *i.e.* by reduction, a splendid colouring matter is formed. This colouring matter is identical with hydrobilirubin

(Maly) and urobilin (Jaffes'). Hæmoglobin itself similarly treated yields the same colouring matter, and it is shewn that urobilin is a changed decomposition product of hæmoglobin, and that bilirubin and biliverdin are intermediate stages in this transformation. The quantity of urobilin excreted within a certain time is the measure of the destruction of red blood-corpuscles.

THE SPERMATOZOA OF CERTAIN VERTEBRATES.—F. Miescher, *Verhand. d. naturf. Ges. in Basel*, VI., 1874, 138.—The sperma, easily to be obtained from the enormously enlarged testicles during the period of heat, consists exclusively of spermatozoa suspended in a weak solution of salt, which only contains traces of alkali-albuminate. The spermatozoa are best obtained by acidulating the fluid weakly with acetic acid, whereby a thick powder-like precipitate falls, which is then well washed with water. The quantity of alkali-albuminate in ripe semen is exceedingly small. A similar effect to that of the acetic acid is produced by a ·5 to 1 per cent. solution of chlor. calcium or chlor. barium. The fresh sperma dried in vacuum contains 18·78 per cent. N, 11·31 per cent. P, estimated as P_2O_5 and 0·278—0·28 S. The quantity of phosphorus is higher than in lecithin, that of N is higher than that of albumen, and that of S less than any other cellular tissue. The fixed solid in the glands was 22·8 per cent., in a completely ripe testicle 25·5. In 100 parts of dried semen there were 13·72 to 14·72 pts. of substances soluble in ether, and 82·28 to 86·5 insoluble therein. 100 pts. of the etherial extract contained 52·46 of lecithin, the remainder being cholesten and fat. The spermatozoa, exhausted with watery hot alcohol and ether, contained in three analyses, 5·34—5·46 p. c. P, 0·2 p.c. S, 20·7—21 p. c. N. The great constancy of S shews distinct combinations. In fact the exhausted spermatozoa consist exclusively of a compound of a base, of "protamin" with nuclein, which here plays the part of an acid. Protamin is obtained by extracting the sperma exhausted of fat, with 1 to 2 p. c. HCl. Evaporate the greater part of the excess of the acid, and precipitate with platinum chloride. A precipitate at first resinous, afterwards gritty and crystalline—of chloride of promatin-platinum-chloride—is obtained. By washing out with water, decomposing with H_2S, the chloride of protamin, which crystallizes with difficulty, is obtained. One can also employ HNO_3, when the crystalline nitrate of protamin is obtained. The analysis shewed the composition of protamin to be $C_9H_{20}N_5O_2(OH)$. On treating protamin with concentrated HCl, a xanthine-like body is formed. The protamin appears first in the testicle at the time of heat—it is absent four or six weeks before this time.

Nuclein is obtained from the residue after extraction with 1 p. c. HCl, by treating it with weak soda solution in the cold. After a few minutes it must be filtered, so that albuminous bodies do not go into solution. The nearly colourless and clear solution is neutralised with HCl, and in order to get the nuclein better precipitated, alcohol is added. Standing for several days under absolute alcohol, on washing out with water to remove the salts, and after extraction with alcohol and ether, the nuclein is obtained pure. It is amorphous, colourless, easily soluble in soda, ammonia and phosphate of soda (compare W. Müller, *Jour. of Anat. and Phys.* VIII. 431). The solutions exhibit—so long as some undissolved nuclein is suspended in them—an acid reaction. Nuclein is therefore an acid. Nuclein does not belong to the class of albumens; it neither gives Millon's reaction, nor the violet coloration with copper sulphate in alcoholic solution, nor the xanthoproteine reaction, and it contains no sulphur. From the analysis of the baryta compound, and also from that of the fresh nuclein, its formula is $C_{29}H_{49}N_9P_3O_{22}$. The *phosphorus therein is contained exclusively as phosphoric acid;* by continued boiling of nuclein with concentrated HCl, one obtains in the fluid quite as much phosphoric acid as on burning with saltpetre. The nuclein in the sperma is not completely saturated with the protamin. The compound of nuclein and protamin conducts itself very curiously with a 10 per cent. solution of NaCl; it swells up, and the individual particles have a double contour. There is a chemical decomposition between the NaCl and the nucleo-protamin; protamin goes into solution, and the Na of the NaCl unites with the nuclein. As the mean composition of pure spermatozoa from the vas deferens we have

Nuclein	48·68
Protamin	26·76
Albuminous Stuffs	10·32
Lecithin	7·47
Cholesterine	2·24
Fat	4·53

No protamin was found in the sperma of the frog, carp and bull.

Also "*On the Chemical Composition of the Spermatozoa.*" The same author finds that after digestion for 6 to 10 hours in gastric juice the tails of the spermatozoa disappear, and the heads can be isolated in this way. The heads contain 4·7 to 4·8 per cent. P, and 1·7 to 1·78 per cent. S. The head contains nuclein, and in addition albumen, and a substance very rich in N. The nuclein obtained from the heads contains 7 per cent. P and 16·41—17·8 per cent. N, and is free of S. The nuclein obtained from pus regularly contains S.—Also "On Protamin, Guanin, and Sarkin as constituents of the Sperma of the Salmon." Picard at Miescher's request reinvestigated this subject (*Ber. d. d. Chem. Gesell.* VII. 1714). P. found a large quantity of guanin and sarkin (about 5 per cent. of the dried sperma) which were not noticed by M. He finds further, that the salts of protamin are not crystallizable; the above finer crystallizates were compounds of guanin and sarkin (Abst. in *Centralblatt*, No. 17, 1875).

Muscle.

DANILEWSKY ON THE RESPIRATION OF MUSCLE.—B. Danilewsky (*Centralblatt für die Medicin. Wissenschaften*, No. 46, 1874) has investigated this subject in Sczelkow's laboratory. It is a well-established fact that muscular activity causes an increased consumption of oxygen in the muscles. As to the significance of this fact, physiologists differ in their opinions (Hermann and Ranke). The absorption of oxygen, as well as the excretion of carbonic acid, both of the active and passive muscles (gastrocnemii of a frog), at different temperatures, were carefully measured by means of a special apparatus devised for this purpose. The muscles were weighted with one gramme. From a table of the gas analyses, which were conducted after the method of Bunsen, he observed that: 1. The quantity of carbonic acid excreted by the tetanised muscle, in comparison with that of the passively moved one, is smaller the higher the temperature. 2. The absorption of oxygen by the active muscle always remains behind that of the passively moved one. It may, therefore, be concluded that this does not stand in direct connection with the process of muscular contraction. This is explained by the unequal greater contact of the passively moved muscle with new air than of the tetanised one. The increased absorption of oxygen by the passively moved muscle produces almost no corresponding increase in the excretion of carbonic acid. One must, therefore, assume that both factors in the respiration are, within certain limits, independent of each other; that muscle can take up a very large supply of oxygen and conceal it for a long time in its plasma without excreting it in the form of carbonic acid. The absorption of oxygen increases in active muscle with the temperature.

"CONTRIBUTIONS TO THE ELASTICITY OF MUSCLE."—M. Blix, *Upsala läken för Förhand.* IX. 555, employed for reinvestigating this subject a new apparatus, the details of which are to be seen in the original. The author confirms the well-known view of Weber that the active muscle possesses less elasticity than the passive one. The tension-curve of caoutchouc is also given, coinciding with results of Horwath, viz. an S-form curve.

Bone.

"On the Normal and Pathological Growth of the Long Bones."—G. Wegner, *Virchow's Arch.* LXI. 44 (Abstract in *Lond. Med. Rec.* No. 96).——"On the Formation and Transformation of Bone."—R. Virchow, *Berlin. klin. Wochensch.* Jan. 4 and 11, 1875 (Abstract in *Lond. Med. Rec.* Nos. 107, 108 and 109).——"Artificial Production of Rachitis and Osteomalacacia."—Heitzmann (*Wiener Medic. Presse,* 1873, No. 45) produced the above results in dogs and cats, by subcutaneous injection of lactic acid and simultaneous diminution in the supply of lime.——"On the Cohesion of Bones."—A. Rauber (*Centralblatt,* Nos. 56 and 60).——"On Normal Resorption and the Interstitial Growth of Bone."—A. Heuberger, *Würzb. Verhandl.* VIII. 19.——"Pathological Growth of Bones."—O. Haab, *Centralblatt,* No. 13, 1875.

"ACTION OF ALIZARIN ON THE TISSUES OF THE ANIMAL BODY."—N. Lieberkühn, *Sitzungsb. d. Marburger Gesellsch. z. Beförd. d. Gesam. Naturwissensch.* 1874, 33 (Abstract in *Centralblatt,* No. 7, 1875), employed a neutral five-per-cent. solution of the soda compound of alizarin prepared synthetically, which is soluble in water. As feeding with this solution was without results, 5—10 cc. of it were injected into the ext. jugular vein of a young dog, which had just cut its milk teeth. In from 10—15 mins. the bones were coloured, but not with the well-known red madder colour as occurs after feeding with madder root, but more of bluish-red, of the colour of alizarin-lime; alizarin alone does not colour the bones in feeding with madder, but at the same time the purpurin. An excellent animal for these experiments is the frog; if a 2 per cent. solution of this substance is injected into a lymph-sac, or into the peritoneal cavity, in a few hours the whole skeleton is tinged bluish-red. Macerated bones also become bluish-red in an alizarin solution. If placed in HCl, they become yellow, from decomposition of the alizarin compound. The injection of this substance is therefore very valuable for studying the growth of bones. Other tissues besides the bones are tinged, *e.g.* the heart, muscles of the skeleton, stomach and intestinal canal, brain, spinal cord, nerves, retina, &c.; alizarin was also present in the urine, saliva, bile and fæces.

Joints.

"JOINT AND ATMOSPHERIC PRESSURE."—Chr. Aeby (*Centralblatt*, No. 15, 1875) shews that for by far the greater number and most important joints of the human body, the atmospheric pressure alone after section of all the soft parts, including the capsule, is quite sufficient to retain the surfaces of the joints in contact; and thereby to hold together the part of the skeleton dependent upon the joint. The shoulder, elbow, radio-carpal, hip, knee, the talo-tibial and talo-navicular joints are all completely alike in this respect.

"On the Form and Mechanics of the Hip-joint." Fr. Schmid, *Deutsche Zeitsch. f. Chirurgie,* v. 1874, 1.——"On the articular Muscles of Man." R. Martin, *Preisschrift,* Erlangen, 1874, pp. 48, 8vo.——"On the Mechanical Conditions in the Structure of the Ankle-joint." Reder, *Allgem.* (*Wiener*) *Militärarztl. Ztg.* 1874, Nos. 47 and 48 (Abst. in *Centralblatt,* No. 18, 1875).

Temperature.

"On the daily range of Temperature in India." Crombie, *Indian Annals of Medical Science,* No. XXXII.

ON THE THEORY OF FEVER.—A. Murri, *Sulla Teoria della Febbre.* Fermo, 1874, 8vo. 132 pp. (from Abstract in *Centralblatt für die Medicin. Wissensch.* No. 1, 1875). The fact that dogs with divided cervical spinal cord cool more rapidly in cool air than healthy dogs, whilst in warm air they become warmer than the latter, led Naunyn, Quincke, and Von Dubczcanski to the supposition that, after section of the cervical spinal cord, the amount of heat given off in consequence of paralysis of the vessels is increased, and simultaneously, the amount of heat produced is increased, and this latter, by the removal of influences inhibitory of the production of heat—these inhibitory influences proceeding from the brain. Substances which produce fever were said to act in a similar way. It is questionable, however, as Riegel has already pointed out, whether dogs with divided spinal cord have not much more lost the capability of giving off more heat in a warm atmosphere. This view is favoured by the absence of the so-called heat-dyspnœa and the influence which heat exercises on the pulse and the blood-circulation in animals not operated on. It has been generally assumed, without any estimation, that the dogs operated on give off more heat in cool air, than the healthy ones. Murri shews that the reverse must be the case; if, for instance, in a comparatively small part of the body (*e.g.* on one ear) there arises vasomotor paralysis, then this part, through increased supply of blood, becomes warmer; when, however, *all* the vessels of the body have been paralysed, it is not obvious how, upon the whole periphery, an increase of blood-supply and giving off of heat should arise. The diminution in the blood-pressure must on the contrary lessen the quantity of blood flowing through the capillaries in the unit of time, and thereby the radiation of heat. In addition to this, the absolute quiescence of the muscles in consequence of paralysis leads to serious stasis, and so a part of the blood is removed from the circulation.

From the experiments of Goltz and Naumann upon the influence of vascular tonus on the circulation, it equally follows that section of the spinal cord must greatly injure the circulation; the simultaneous paralysis of the splanchnici permits of the greater part of the blood accumulating in the abdominal vessels. As a clinical proof that interruption of the spinal cord retards the circulation, the author cites a case of sudden circumscribed compression of the spinal cord in consequence of the penetration of pus; in this case œdema occurred in the paralysed lower half of the body, without either at the bedside or at the sectio there being found any disease of other organs, or any circumstance other than disturbance of the circulation. The experiments of Murri, made upon dogs, shew in fact that after section of the cord the skin is less warm, and gives off less heat than normally. Simultaneously with measurement of the rectal temperature, the temperature of the skin was taken with mercurial thermometers, which were either bound to the skin, or (generally) introduced through a wound, under the skin. The temperature of the skin sank after the operation in large as well as in small dogs, in a cool atmosphere as well as in a temperature of 30° Cent. (86° Fahr.). On increasing the temperature of the air, in the course of an experiment, to 40·2° Cent. (104·36° Fahr.), the temperature of the skin rose only to its original value of 39·6° Cent. (103·3° Fahr.), whilst that of the rectum rose to 41·6° Cent. (106·88° Fahr.) against 40·4° Cent. (104·7° Fahr.) before the operation. Cooling of the skin also takes place when, the temperature of the room being about 25° Cent. (77° Fahr.), the internal temperature rose after the operation. And when, in course of the experiment, the temperature in the rectum had risen above the normal, in spite of regular, frequent, repeated measurements, the skin was never observed to become warmer. It is not to be thought of that the skin, always cooler than normal, should give off greater quantities of heat than normally; it must give off less. The direct measurements of the heat given before and after section of the cord were carried out in the following way. The dogs were placed in a wooden box, at a constant temperature of the room of 24° Cent.; the increase in the temperature which the air in the box underwent, at distinct intervals of time, through the presence of the dog, formed the measure for the amount of heat given off by the dog. It was shewn that the dogs warmed the air of the box much more before the operation than after it. Now, in spite of the diminished giving off of heat, the interior of the animals became colder; they must therefore have produced less heat after the operation. Further, this diminution of production can be explained by the paralysis of the muscles, by the disturbance of the circulation which leads to imperfect supply of oxygen to the organism, by the diminished muscular work of the heart, and by the diminution of the internal friction of the blood-current, etc. Now in opposition hereto in fever more heat is produced than normally under the same conditions; the result of section of the spinal cord cannot therefore be drawn in for the theory of fever. In that, further, no experimental lesion of the nervous system by itself increases the production of heat in the tissues, so falls the theory of the neuro-paralytic nature of fever. And even if septic fever actually had this origin, the generalisation for all fevers is not established.

Murri further divided the cord of dogs in which he had produced septic fever; here the operation had not the above-mentioned cooling influence.

In other experiments the author divided first the cord (which produced a cooling) and then injected fœtid pus under the skin of the dogs, whereby their temperature rose quite as in the non-operated-on animals. These operations, whereby the hypothetical "heat-inhibiting centre" in the brain is excluded, speak against the supposition of Quincke and Naunyn, according to whom pyrogenic substances produce an increase of temperature by paralysing the heat-producing inhibitory centre lying in the brain. On the contrary they are easily explained from the point of view of the bio-chemical theory of fever, according to which pyrogenic substances equally with ferments produce abnormal, chemical, decompositions. (This theory is supported by Murri.) Septic fever can be produced even after destruction of the whole lower section of the spinal cord. The observation of Sapalski, confirmed by Von Dubczcanski and Naunyn, that feverish animals in a cool atmosphere cool more rapidly than sound ones, Murri cannot corroborate throughout, the experiments being analogous, and in a somewhat modified form, and performed only on rabbits. Sometimes the feverish (septic) animals cool more, sometimes the sound ones. However, to accede to this analogy between feverish animals and animals with divided spinal cord, still this analogy is no identity, for then the winter-sleep, which also shews this analogy, would be identical with "fever." Further clinical observation shews that not in all feverish diseases do the patients cool more rapidly than healthy individuals.

Senator (and Heidenhain) considers that in fever the cutaneous actions are more excitable than normally, and by frequent contractions limit the amount of heat given off. The author believes that he is enabled to refute this opinion, from observations on typhoid and pneumonia, where continually and for a long time a regular warm skin is to be found (although Senator himself had shewn that in spite of a hot skin the arteries do not require to be widened *ad maximum*, and can even be narrowed, Filehne). In a patient with pneumonia, Murri measured the temperature under the toes; it remained for hours constant, 37·8° to 37·9° Cent. (100·04° to 100·22° Fahr.), with an axilla temperature of 40·5° to 40·6° Cent. (104·9° to 105·08° Fahr.): the relation of these numbers is quite the same as exists in health.

Murri further questions the difference between feverish and healthy individuals which Senator proposed, viz., that the regulation of heat is insufficient. The muscular work of a healthy person lasts only a limited short time, and first during the pause the body rids itself of the surplus heat; if here the heat-forming process (muscular exercise) was constantly continued, then the healthy individual would also no longer be able to regulate. The fever process goes on without a break, and it is not proved that the fever patient would not regulate his condition of heat quite as quickly as a sound person, if the feverish excess of production gave him the necessary pauses. The above-cited experiment of Sapalski, together with Senator's view, that his feverish dogs cooled considerably in cool calorimeters, supports the view that in septic fever the capability of giving up heat is not diminished, or that this is quite a secondary matter for the theory; and appears to the author to prove that the higher temperature is chiefly dependent simply upon the increased production, without, however, admitting the reliability of Senator's deduction for all cases.

Murri further shews how all clinical processes (incubation, predisposition, immunity, spontaneous origin, etc.) are throughout explicable with the light of the bio-chemical fever theory, whilst from the neuro-paralytic point of view they are quite inexplicable. The latter also does not explain the qualitative metamorphic changes in fever.

The author then enlarges upon his views of fever, already fully explained in the *London Medical Record*, November 26, 1873, and replies to Hüter, who had made as the outset of his theory a single observation on frogs, although he had not proved in his frogs the essential phenomena of fever, *e.g.* increased heat, whilst notwithstanding these animals, as former investigations have shewn, have a temperature which is slightly higher than their surroundings, *i.e.* shew a proper production of heat. In addition, this or that phenomena might be present in a certain fever (septic) and absent in another kind, so that "globulöse Stase," as such, does not belong to fever. Murri regards Hüter's theory as laid aside.

Milk.

"Quantitative estimation of the Fat of Milk." M. Löwit, *Pflüger's Arch.* IX. 65.——"Investigations on Human Milk and the Milk of the Cow as food." Ph. Biedert, *Virch. Arch.* 1874, LX. 352 (Abst. in *Centralblatt*, No. 5, 1875).

ON THE GLOBULES OF MILK.—De Sinéty, *Arch. de Physiol.* 1874, 479, has repeated the experiments of Kehrer, and also those of Schwalbe, both with positive results. This apparent contradiction is explained thus: absolutely fresh milk taken from the mammary gland (of a woman, and from a guinea pig) shewed considerable changes after it had stood for one to two hours. The globules of absolutely fresh milk can be caused to flow together under the microscope, which certainly speaks against the existence of a membrane. If a watery solution of aniline-red is added to this milk all the milk-globules remain colourless, which would not be the case if they had an albuminous envelope. After standing an hour, the milk contains a not inconsiderable number of corpuscles, which refract light less strongly and are coloured by aniline-red. With longer standing the number of these corpuscles increases. If the butter is removed from fresh milk, then the butter-milk contains numerous globules which take up aniline, but never the remains of these corpuscles. The butter also contains those corpuscles together with others which do not become coloured. The author concludes that the milk-globules in the animal organism are devoid of a membrane, that all those structures described by authors as membranes and caseous envelopes of the milk-globules are secondary productions, due either to the physiological changes which the milk like the blood undergoes outside the organism, or to the coagulating reagents of the investigator.

Miscellanea.

"Physiological action of Jaborandi." Carville, Biolog. Society of Paris, Nov. 28th, 1874 (Abst. in *Lond. Med. Recd.* No. 103.——"Action of Jaborandi and Atropia on perspiration." *Progrès Médical,* Feb. 13th, 1875.——"On the action of Jaborandi." J. N. Langley, *British Med. Journal*, Feb. 20th, 1875 (Abst. of both papers in *Lond. Med. Recd.* No. 113).——"Action of Jaborandi bark." Galippe, *Progrès Médical*, Feb. 13, 1875.——"On Jaborandi." S. Ringer and P. Gould, *Lancet*, 1874, I. No. 5.——"Physiological Spectrum Analysis"—of certain yellow colouring matters, indigo in the urine, colouring matters of the bile, etc. K. Vierordt, *Zeitsch. f. Biologie*, 1874, x. 21.——"Bacteria and putrefaction." A. Hiller, *Centralblatt*, Nos. 53 and 54.——"Action of ammoniacal salts on the animal organism." Lange, *Arch. f. exp. Path. u. Pharmak.*, 1874, II. 364 (Abst. in *Centralblatt*, No. 14, 1875).——"On the action of chloral and trichloracetic acid." A. Tomaszewicz, *Pflüg. Arch.* IX. 35 (Abst. in *Centralblatt*, No. 16, 1875).

HARNACK ON THE ACTION OF APOMORPHIN ON MAMMALS AND THE FROG.—E. Harnack (*Archiv für experiment. Pathol. und Pharmac.*, 1874, vol. II., from the abstract in *Centralblatt für die Med. Wissensch.* No. II. 1875) says that, from the previous investigations on the action of apomorphin, it was believed that in this substance we possessed an emetic which, apart from its emetic action, did not exercise any important secondary effect on the organism. From the author's experiments, however, it appears that this substance acts on certain parts of certain animals in a very intensive and deleterious manner. To exclude the act of vomiting, and to obtain as clear a view as possible of its secondary effects, the author experimented on rabbits, which do not possess the faculty of vomiting. It was shewn that even 10—30 millegrammes (0·4 grs. to 2 grs.) of apomorphin produce death in the rabbit, whilst ½ to 10 millegrammes (0·2 to 0·4 grs.) are sufficient to produce important changes in certain bodily functions. The smaller doses threw the animals into the highest excitement and uneasiness; they ran to and fro in the room, crawled into dark corners, and were very frightened. In addition, in most there was salivation. This condition ceased after a few hours, and the animals returned to the normal. If the doses employed are greater, unsteadiness of gait soon sets in, the posterior extremities being first affected; the animal suddenly falls over in convulsions, the respiration ceases, and death occurs, and cannot be averted by artificial respiration. The frequency of the respiration is at first enormously increased, and, according to the author, this increase is to be ascribed to stimulation of the respiratory centre, and it occurs even after division of the vagi. This stimulation is followed by a diminution of the excitability, and ultimately by paralysis of the centre. Regarding the question, whether the convulsions are simply the consequence of the disturbance of the respiration, or are dependent on stimulation of certain central organs, the author seeks to decide by experiments on chloralised animals. These experiments shewed, first, that in such animals convulsions are absent, and secondly, that animals narcotised with chloral can bear much larger doses of apomorphin, and that death is accelerated by the occurrence of convulsions. The absence of convulsions the author seeks to ascribe to the paralysis by chloral of those central organs, upon whose stimulation by apomorphin the convulsions depend; he assumes a direct stimulation of the central organs, and so it appears to him possible that conversely there would be difficulties in diminishing or paralysing by narcosis of the motor centres stimulated by apomorphin. The author then touches the question as to the identity of the vomiting and respiratory centres, and from experiments on narcotised dogs decides against this view. He says, "Proceeding on the assumption of the identity of the respiratory and vomiting centres, one must expect that in such narcosis apomorphin is able without hindrance to produce vomiting, in that the respiratory centre has not lost its excitability, and we have seen that in rabbits in this condition also, the centre undergoes a powerful stimulation by apomorphin. One cannot, however, produce vomiting during the narcotic condition." In the frog the author observed first a stimulation, and then a complete paralysis of the centre of voluntary movement; later the irritability of the transversely striped muscles is diminished, and with large doses completely paralysed, without their becoming rigid. This paralytic action on transversely striped muscles, apomorphin possesses in common with several other emetic substances, *e.g.* emetin, tartar emetic, cyclamin, and asclepiadin—from Radix Vincetoxici, a substance which, in its action, according to Harnack, is analogous to apomorphin. Lastly, the author attempts to establish, experimentally, in what way the increase in the frequency of the pulse accompanying vomiting arises; whether it owes its origin to a diminution in the tonus of the vagus, or is due to stimulation of the accelerating apparatus of the heart. Supported by the fact that stimulation of the accelerating nerves produces increase of the frequency of the pulse without increase of the blood-pressure—that, on the contrary, diminution of the tonus of the vagus is accompanied by increase of blood-pressure—the author observed the pulse and blood-pressure after injection of apomorphin into dogs, and found that increase in the frequency of the pulse produced by the act of vomiting is not accompanied by an increase of the blood-pressure; therefore that the relations existing during the act of vomiting are analogous to those which are produced by artificial stimulation of the accelerating nerves.

"*Action of Apomorphine,*" C. David, *Comptes rendus*, Aug. 24, 1874 (Abst. in *Centralblatt*, No. 17, 1875).

Thoma on the Cement-substance of Epithelium.—R. Thoma (*Centralblatt für die Medicin. Wissenschaften*, No. 2, 1875), in studying the physiological and pathological changes in the epithelium of the frog's tongue, discovered a method by which in the living animal an excretion of indigo in the cement-substance of the above organ, as well as in certain parts of the alveolar mucous membranes, could be produced. This cement-substance appears as a fine deep-blue coloured network, stretching regularly over the whole tongue, between the colourless epithelial cells, and lying somewhat below the level of the free epithelial surface. The method is the following. A solution of pure sulph-indigotate of soda is prepared by diluting, with an equal volume of distilled water, a saturated and filtered watery indigo solution. This is injected, under a constant pressure, into the median abdominal vein of a frog, so that in the course of two to four hours, from four to six cubic millimètres of the indigo solution are introduced into the body of a medium-sized rana temporaria or esculenta. Simultaneously the tongue is irrigated by a 1·5 per cent. solution of chloride of sodium, in consequence of which pronounced widening of the vessels occurs, specially in the arteries, together with great acceleration in the blood-current. The microscope shews, that the blood is coloured slightly blue. After a short time the connective-tissue becomes blue, whilst muscular fibres and epithelium shew no obvious coloration. First, after two or three hours, does the cement substance shew a deep-blue coloration.

Text-Books.

Leçons sur l'Appareil vaso-moteur (Physiologie et Pathologie). Tome premier, par A. Vulpian, Paris, Librairie Germer Baillière, 1875.——Chimie appliquée à la physiologie, à la pathologie et à l'hygiène, par E.-J. Gautier, 2 vols. Paris, F. Savy, 1874.

INDEX TO VOLUME IX.

CAMBRIDGE: PRINTED BY C. J. CLAY, M.A. AT THE UNIVERSITY PRESS.

Journal of anatomy