MULTIPLE ANOMALY IN A VERTEBRAL COLUMN. By E. BARCLAY-SMITH, M.A., M.D., *University Lecturer in Advanced Human Anatomy, Cambridge.*

PROFESSOR ELLIOT SMITH has most kindly presented to the Cambridge University Museum of Human Anatomy parts of a skeleton including a skull, which is complete and in good condition, together with a few ribs, and a vertebral column. The vertebral column is probably unique as an example of extreme and extensive departure from the normal form.

The bones are those of an Egyptian, and Professor Elliot Smith has kindly furnished me with the following history:—

"The imperfect skeleton of a young woman found in Mr J. E. Quibell's excavations at Sakkara (Egyptian Government's 'Service des Antiquités'). The burial was disturbed during the building of a Græco-Roman temple, and part of the skeleton was missing. No objects of any kind were found with the skeleton, but it must have been Ptolemaic or earlier. On the site where the skeleton was found there was a series of superimposed burials dating from the fourth dynasty, each later series cutting into its predecessor. As in the earlier periods, the burial-place was a necropolis, used exclusively by the aristocracy, *i.e.* the bodies were buried in extensive stone tombs. It is highly probable that this body was buried in the Persian or Ptolemaic period, *circa* 600 or 500 B.C."

SEX AND AGE.

The evidence determining the sex of the bones was furnished by the skull, which is of a marked female type. The conclusion that the bones are female was arrived at after giving full consideration to the difficulty in determining the sex of an Egyptian skeleton. The cranium is smooth and globular; the external occipital protuberance is practically non-existent; the mastoid process is very small, and its projection slight; the zygomatic arches are very slender; the frontal and parietal eminences are well marked; the superciliary ridges are faint; the orbital aperture is rounded, and its margins thin and sharp; alveolar prognathism is present, but this prognathism is not shared by the incisor teeth, which are vertically set.

The age of the individual was between twenty-one and twenty-five years, and probably nearer the former than the latter. There is no sign of sutural synostosis in the cranial vault, but synostosis between the basioccipital and basisphenoid has taken place. The maxilla is provided with a perfect set of beautifully formed teeth, in which there is no trace of decay.[1] In the vertebral column there are indications of imperfect fusion of the terminal epiphyses on the spinous processes, and the epiphysial discs coating the upper and lower surfaces of the vertebral bodies are still evident. According to Keibel and Mall the epiphysial discs fuse with the body of a vertebra about the twentieth year, and the line of suture is visible usually for a year longer. The partial independence of the epiphyses is not evident to the same extent throughout the column. The incomplete fusion of the discs is most marked in the 4th, 5th, and 6th thoracic vertebræ, and, while appreciable in the cervical region, no line of fusion is visible in the lumbar region below the 1st lumbar vertebræ, where it is very faintly indicated.

In the lower thoracic and lumbar regions the partial independence of the terminal epiphyses of the spinous process is most pronounced; this partial independence can also be identified in the upper thoracic region (in those cases where the spinous process is complete and unbroken), and in the 7th and 8th (!) cervical. The 1st sacral vertebra, as will be noticed more fully hereafter, is partially independent; between it and the 2nd sacral there is a wide interval indicating the position of an unossified intervertebral disc. There is evidence that the intervertebral discs between the other sacral segments have not undergone complete consolidation.

THE MOST CONSPICUOUS ANOMALIES.

Anomalous conditions are present in all regions of the vertebral column. The most conspicuous anomalies may be summarised as follows:—

Cervical Region.—(*a*) The presence of eight vertebræ to which the term cervical may be applied

(*b*) The atlas is synostosed to the occipital bone.

(*c*) The axis and 3rd cervical vertebra are fused together and form a composite mass.

(*d*) The 7th cervical vertebra has an interrupted neural arch. The interruption is dorsi-median, the two laminæ being mutually independent and the spinous process subdivided.

(*e*) The 8th cervical vertebra is provided with a small unilateral cervical rib; otherwise it presents features characteristic of a cervical vertebra.

[1] The incisors show evidence of lateral filing, the intervals between them being relatively wide. Professor Elliot Smith tells me that this is the only case of lateral filing of the incisors he has ever found.

Thoracic Region.—(*a*) The joints between the 11th and 12th thoracic vertebræ are peculiar in that the opposed articular processes are lumbar in type on the one side and thoracic in type on the other.

Lumbar Region.—(*a*) The lumbar vertebræ are all more or less distorted, suggesting a lateral curvature in this region.

(*b*) In the 3rd, 4th, and 5th lumbar vertebræ the neural arches are interrupted.

(*c*) In the 5th lumbar vertebra there are two interruptions, a part of the neural arch being an independent ossicle.

Sacral Region.—(*a*) The sacrum as a whole is distorted, presenting a lateral curvature.

(*b*) The 1st sacral vertebra is partially lumbarised. Its neural arch presents two interruptions, and in consequence is in part an independent ossicle.

A detailed description of the individual vertebræ comprising the vertebral column may now be given.

Cervical Region.

Atlas.—The 1st cervical vertebra is fused with the skull in its whole circumference, but in the following features it presents a partial independence:—(1) Above the conspicuous anterior tubercle marking the front of the anterior arch is a fairly large foramen, limited above by the hinder edge of the basioccipital. (2) A foramen on either side, bounded below by the root of the posterior arch of the atlas, above by the occipital bone, served for the transmission of the vertebral artery and the 1st cervical spinal nerve. This atlanto-occipital foramen, as it may be called, is decidedly larger on the right side than on the left. (3) The lateral processes, though closely approximated to the basis cranii, are separated therefrom by intervals.

The fused atlas is asymmetrical as regards its position relative to the skull, and this asymmetry is of two kinds.

The bone may be regarded as rotated leftwards about a vertical axis. This rotation is evidenced by the following features: (1) the median tubercle on the anterior arch is tilted rightwards; (2) the tip of the left lateral process is opposite to the corresponding mastoid process, in contrast to the right lateral process, whose line of projection falls considerably behind the right mastoid process.

A further asymmetry is indicated by a general tilting of the bone in a horizontal plane of such a kind that the right half of the bone is on a lower level than the left. The tilting is indicated by the following:—(1) The left half of the neural arch is flattened, and so squeezed, as it were, against the skull that it is to some extent on the same plane as the skull wall itself. The right half of the neural arch is relatively thicker, not so indiscriminately fused with the skull, and by its salience is responsible for the right margin of the pseudo foramen magnum being at a lower level than the left margin. (2) The left lateral process is deflected downwards, its extremity being at a much lower level than its root—a narrow slit-like interval intervenes between it and the cranial wall. The right lateral process is horizontally disposed; the interval between it and the cranial wall is appreciably wider. (3) The left lateral mass, though fused with the skull, is obviously thinner than that on the right; the difference may be estimated by comparing the vertical distance between the anterior condylar foramen and the anterior edge of the articular surface of the atlas on either side: this distance is 17 mm. on the right side, but only 11 mm. on the left.

The two lateral processes present an interesting contrast. The ventral or costal bar of the right process is very slender, while the corresponding bar on the right side is thick. The difference is correlated with a larger costo-transverse foramen on the left side.

The articular surfaces correspond to the inferior articular surfaces of a normal

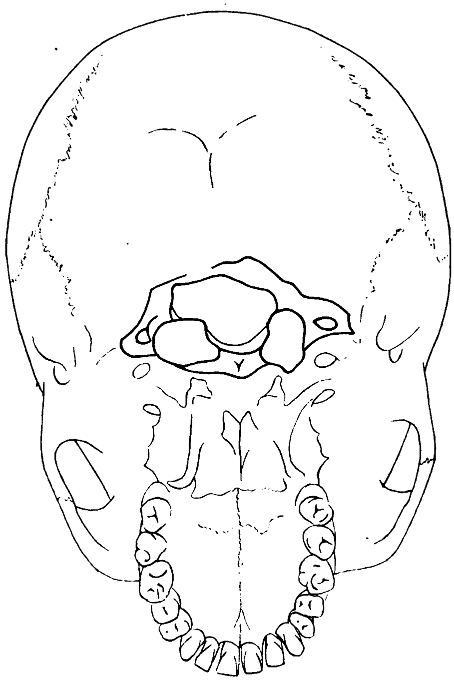


FIG. 1.—Skull viewed in normabasilaris. The fused atlas is indicated in heavy outline.

atlas. They are relatively very extensive, and their irregular outlines present a great contrast to the usual circular form. Each articular surface is somewhat pear-shaped; the narrow end is in front, and extends on to the anterior arch. Of the two surfaces the left is the more extensive, is longer coronally than it is sagittally, and involves the anterior arch to a greater extent. The right surface, on the other hand, is longer sagittally than it is coronally. The articular surfaces do not exhibit the normal flattening: the right surface is decidedly convex from side to side and slightly so from before backwards; the left surface is undulating from before backwards and slightly convex from side to side. Each articular surface lips on to the mesial aspect of the bone where a small vertically disposed facet is present. This vertical facet is undoubtedly a facet of occasional contact with the lateral aspect of the odontoid process of the axis (*q.v.*).

Axis and Cerv. 3.—The two vertebræ are represented by a common mass. The fusion involves the bodies, laminæ and spinous processes of the two vertebræ; the lateral processes and the pedicles (which bound the intervertebral foramina on either side) being the only parts which retain their independence. The fusion of the two laminæ on the left side is not quite complete, as a foramen interrupts their line of junction. This foramen is rounded and probably transmitted a vein which established a communication between the intra-spinal veins and the posterior spinal

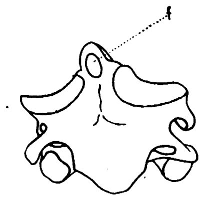
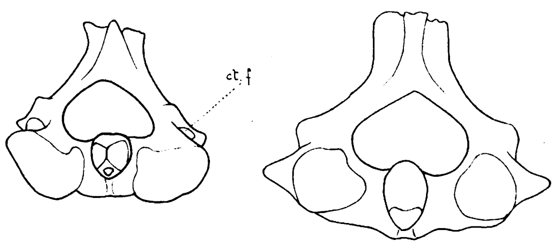


FIG. 2.—Composite vertebral mass resulting from fusion of axis and cervical 3, viewed from in front; *f*, lateral facet on odontoid process.

plexus. Between the pedicular parts of the two vertebræ, on either side, is a large rounded intervertebral foramen; a distinct horizontal ridging, extending backwards from the posterior margin of this foramen, indicates the line of fusion of the conjoint articular processes.

The odontoid process is small and short. It is somewhat obliquely disposed, projecting upwards and slightly rightwards from the main mass of the bone. The feebly marked neck is indicated by a slight constriction. A small facet, diamond-



A B

FIG. 3.—A, axis viewed from above compared with B a normal axis. *ct*, costa-transverse foramen.

shaped in outline, occupies its anterior aspect and indicates a contact surface for the anterior arch of the atlas. The articular facet on the odontoid process is very much smaller than the corresponding facet on the atlas. From the great disproportion between the two it may be assumed that very considerable displacement could occur at the atlanto-axial joint during life. The part of the odontoid process above the constriction marking the neck may be likened to a three-sided pyramid, as it presents two lateral flattenings, each looking backwards and outwards and separated from one another by a median dorsal ridge. These two flattenings are so smooth that there can be little doubt as to their being articular, and during life were capable of approximation to the vertically disposed facets on the lateral parts of the fused atlas (*vide supra*).

The superior articular facets which occupy the upper surface of the body of the axis present certain noteworthy features. The coronal diameters of these facets are relatively long, a contrast to their sagittal diameters, which are relatively short. This disproportion is very apparent in comparing their measurements with those of a normal axis where the two diameters are nearly equal.

		Coronal diameter. mm.	Sagittal diameter. mm.
Anomalous axis	R. Sup. art. surf. . .	19·5	12
	L. Sup. art. surf. . .	18	12·5
Normal axis	R. Sup. art. surf. . .	17	16·5
	L. Sup. art. surf. . .	15	16

As the anomalous axis is considerably smaller than the normal axis with which it is compared (*vide* fig. 3), a comparison of the coronal diameters does not sufficiently express their exaggeration in the former. The coronal elongation is due to an extension of each articular surface on to the root of the odontoid process ; as a result the median interval between the two articular surfaces is much smaller than in the normal bone. The sagittal shortening is associated with the fact that the articular surface is disposed on the centrum only, and does not involve the pedicle, as is the case in the normal axis. The superior articular surface is to a certain extent displaced forwards. This displacement is obvious when examining the axis from above and comparing it with the normal bone (*vide* fig. 3). In the former the articular surface is well in front of the lateral process and the opening of the costo-transverse foramen is visible behind it; in the latter the articular surface is opposite to the pointed lateral process and hides the costo-transverse foramen from view. The superior articular surfaces exhibit a further peculiarity in that they are definitely concave from side to side and gently undulating from before backwards, a great contrast to the flattened articular surfaces exhibited by the normal axis.

I have described the corresponding articular surfaces on the atlas and the axis in some detail, as they afford evidence that the joints between these two vertebræ enjoyed such extensive and free movements that they compensated largely, if not completely, for the lack of mobility between the atlas and the skull.

The fused mass of the two vertebræ, when viewed from in front, is seen to be asymmetrical. This asymmetry is due to a vertical compression or closer approximation of the two vertebræ on the right side. The vertical compression may be measured by comparing the vertical distances on the two sides between the plane of the superior articular surface and the lower limit of the inferior articular process. This distance is 27 mm. on the right side and 32 mm. on the left. The squeezing together of the two vertebræ on the right side is associated with (1) a rightward tilting of the odontoid process ; (2) a closer approximation of the two lateral processes on the right side : a wider interval between them on the left side ; (3) a more complete fusion of the two laminæ on the right side than on the left, where incomplete fusion is indicated by the presence of a foramen (*vide supra*).

The vertical compression of the right side of the composite mass, including the 2nd and 3rd cervical vertebræ, served perhaps as a compensation for the closer approximation of the atlas to the occipital bone on the left side.

The lateral processes of the two vertebræ forming the composite mass exhibit well-defined costo-transverse (vertebrarterial) foramina. These foramina are larger on the left side, evidencing, as did the atlas, the larger size of the left vertebral artery. The plane of the costo-transverse foramen in the lateral process of the axis is decidedly behind that of the corresponding foramen in the 3rd cervical vertebra. This holds good on both sides, and indicates that the vertebral arteries, as they passed from one vertebra to the other, sloped obliquely upwards and backwards.

The inferior aspect of the body of the lower vertebra (C. 3) is markedly convex from side to side, the lateral extension of the inferior surface ascending higher on the right side than on the left. These lateral extensions are very smooth, indicating that they were in extensive and direct contact with the elongated lateral lips of the superior surface of the vertebra below (C. 4) during life.

The conjoint spinous process is no larger—in fact it is smaller—than that of a normal axis. It is relatively short and presents a shallow inferior groove bounded terminally by two slightly divergent tubercles. The feeble development of these tubercles indicates that the tendency of the spinous processes of the 2nd and 3rd cervical vertebræ to bifurcate is not so marked as in a normal spine.

Cerv. 4.—This vertebra exhibits slight asymmetry. The neural arch is tilted somewhat leftward. The upper aspect of the body is deeply concave from side to side, and is marked on either side by exaggerated lateral lips. The lateral lips are very smooth and evidence extensive contact with the lateral aspects of the body of the vertebra above.

The spinous process is short, slender, and pointed; it is remarkable in exhibiting no trace of bifidity.

The two superior articular processes present unequal facets, the right facet being the larger. The facets are not co-extensive with the corresponding facets on the vertebra above (C. 3). The disproportion between the opposed facets of the two vertebræ was estimated by measuring and comparing their vertical extents.

		Vertical extent of articular facet.
Right side	Inf. art. facet on C. 3 =	14 mm.
	Sup. art. facet on C. 4 =	11·5 ,,
Right side	Inf. art. facet on C. 3 =	13 ,,
	Sup. art. facet on C. 4 =	8 ,,

The disproportion between the extents of the mutually opposed surfaces of the articular processes is evidence that considerable displacement could occur between the two vertebræ. That the joints between the two vertebræ enjoyed a considerable range of movement is also made apparent by fitting the two bones together and estimating the thickness of the intervertebral disc between them: this disc must have been relatively very thick if its position in the neck region be taken into consideration. The marked lateral lips on either side of the body of C. 4 and their extensive areas for contact with the lateral aspects of the body of C. 3 are additional features favouring free mobility. A very movable joint between the 3rd and 4th cervical vertebræ would not only be a compensation for the fusion which exists between axis and C. 3, but would take a share in neutralising the absence of the occipito-atlantal joint.

Cerv. 5 exhibits a slight rightward tilting of the neural arch on the body, *i.e.* a condition the reverse of that found in C. 4. This vertebra alone in the cervical group (with the exception of the composite vertebral mass representing axis and C. 3) exhibits the essentially human characteristic of a bifid spinous process. The bifidity is not symmetrical: the right fork of the spinous process is long and oblique, while the left is straight and stunted.

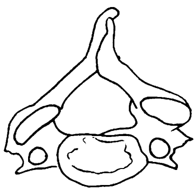


FIG. 4.—Cervical 7 viewed from above. Note the overlapping of the dorsal prolongations of the two laminæ.

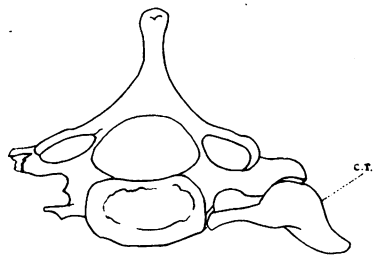


FIG. 5.—The 8th (cervical?) vertebra viewed from below, the detached costal process or rib *c.t.* being placed *in situ.*

Cerv. 6 resembles C. 5 in exhibiting a rightward tilting of the neural arch; but the tilting is very slight and scarcely noticeable. A pointed spinous process showing no trace of bifidity is a feature worthy of note.

Cerv. 7 is remarkable in having an incomplete neural arch, due to lack of dorsi-median fusion. The lamina on each side is prolonged backwards into a median process. The two processes or bilateral constituents of a normal spinous process are not divergent, but overlap one another, the left process tending to cross above the right. Each process presents the appearance of having a distal epiphysis, the fusion of which has not been fully attained.

Cerv. 8 may be included in the cervical group, although it exhibits some transitional features.

On the right side the costal process, which measures 35 mm. in length, is detached and simulates to some extent a thoracic rib. The head of this immature rib is small, its neck elongated involving nearly half the whole length of the bone, its tuberosity large and faceted, and its free extremity pointed. In brief, it presents the usual characteristics of a cervical rib. The vertebra presents corresponding costal facets on the right side, a small capitular facet and a more extensive facet on the transverse process, which is large and well developed.

On the left side a small stumpy process projects from the body of the vertebra at a point corresponding to the position of the capitular costal facet on the right side.

The transverse process is unfortunately broken off short, but there is evidence of an incomplete and partially subdivided costo-transverse foramen.

In other respects the vertebra possesses the features of a typical vertebra prominens. The spinous process is long and horizontally disposed. The upper aspect of the body is laterally lipped and cervical in type, while its lower aspect is thoracic in type.

Thoracic Region.

The thoracic vertebræ present a marked contrast to those in the cervical and lumbar regions. They may be described as normal both as regards number and general anatomical features. They call for no special comment, but a few points of interest may be noted.

The capitular costal facets on some of the thoracic vertebræ present certain peculiar features. In Th. 2, 3, and 4, the demi-facets at the lower edges of the bodies of the vertebræ are practically on a horizontal plane, and are disposed upon the inferior aspect of buttress-like ridges, which project from the lateral aspects of the vertebral bodies. In Th. 5, 6, 7, 8, and 9, the buttress-like ridge becomes progressively thicker, and the demi-facet more extensive and more obliquely disposed, being directed outwards as well as downwards.

Such buttress-like projections supporting the upper facet of the central contribution to the costo-central joint is a normal feature, but they are not usually so well marked, and are confined to the middle members of the thoracic series, to Th. 5, 6, 7, and 8 as a rule.

The costal demi-facets at the upper edges of the vertebral bodies, with the exception of those on Th. 10, 11, and 12, are concave sagittally and convex vertically. This feature is perhaps best marked on Th. 7, where the facet is definitely trochleoid in appearance.

This trochleoid condition of the capitular facet may often be found in the normal spine, but when present it is usually confined to Th. 6, 7, and 8. The trochleoid facet suggests a costo-central joint akin in plan to an ephippial joint, as exemplified by the carpo-metacarpal joint of the thumb. Unfortunately, the corresponding ribs have not been preserved, and consequently the correlated conditions of their capitular articular surfaces cannot be determined. The central facets alone, however, are sufficient to indicate that during life the play between the ribs and the vertebral column must have been considerable, and that the movements of the heads of the ribs were most extensive in two planes at right angles to one another.

Th. 4, 5, and 6 were examined for the characteristic aortic flattening on the left side. Not only was the usual aortic flattening absent, but the bodies of these vertebræ are more distinctly flattened on the right side than on the left. Further, on fitting all the thoracic vertebræ together, a distinct vertical flattening of the column formed by the superimposed vertebral bodies could be traced, inclining downwards and forwards from the right side of Th. 4 to the front of Th. 12.

Such flattenings are not absolutely diagnostic, but possibly a right aortic arch is indicated thereby. Whether the right aortic arch was associated with an allied transposition of viscera or not is open to surmise, but need not be discussed.

Thoracic 11.—The inferior articular process on the left side is lumbar in type: the facet is convex and directed outwards. The inferior articular process on the right side is thoracic in type: the facet is flattened and directed forwards.

Thoracic 12.—The superior articular processes exhibit a condition correlated with that found in Th. 11: the left is lumbar in type, the facet being concave and directed inwards, while the right is thoracic in type, the facet being flattened and directed backwards.

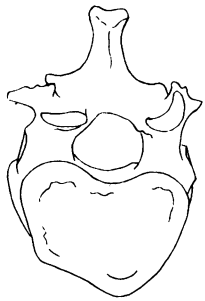


FIG. 6.—Thoracic 12 viewed from above. Note the lumbarised condition of the left superior articular process.

Lack of symmetry in the opposed articular processes of the 11th and 12th thoracic vertebræ, lumbarised on the one side, of a thoracic type on the other, is not at all an uncommon condition. Such a disposition would facilitate lateral flexion of the trunk. I have found lumbarisation of these articular processes to be present more frequently on the left side; under these circumstances lateral flexion of the trunk rightward would be facilitated.

Lumbar Region.

Lumbar 1 calls for no detailed description, as it presents normal features, with the following slight exceptions. The body is in some degree a lateral wedge, its vertical depth being slightly longer on the left side than on the right. Both lateral processes are deflected backwards, but the deflection is slightly more marked in the case of the right process.

Lumbar 2, like L. 1, has a body in the form of a lateral wedge, the thick end of the wedge being to the left, but in this case it is more marked, the vertical depth of the body being decidedly longer on the left side.

The right inferior articular process presents marked peculiarities. It is dwarfed and very much smaller than the corresponding process on the left side. The general diminution applies equally to bulk, vertical projection, and extent of articular surface.

Its articular surface may be described as slightly undulating, and is not sharply defined.

The lateral process is more definitely deflected backwards on the right side than it is on the left. The difference in the obliquity of the two lateral processes is more decided than in the case of L. 1 (*q.v.*).

The left pedicle is traversed by a vertical canal. This canal is found close to the junction of the pedicle with the lateral process and superior articular process.

In this vertebra, as is the case with most of the lumbar vertebræ, the mammillary and accessory processes are very strongly marked.

Lumbar 3 is remarkable for having an interrupted neural arch. The interruption takes the form of a slit-like interval behind the right superior articular process, and is of such a kind that the right pedicle bearing the superior articular process is independent of the right lamina bearing the inferior articular process.

The articular processes on the right side are markedly anomalous. The right

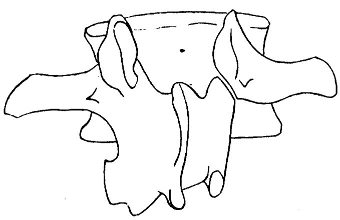


FIG. 7.—Lumbar 3 viewed from behind. Note the interruption in the neural arch on the right side.

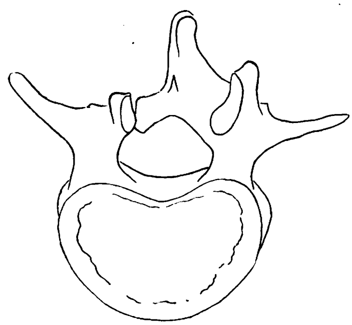


FIG. 8.—Lumbar 3 viewed from above. Note the position of the interruption dorsal to the dwarfed right superior articular process.

superior articular process is disposed on a plane considerably anterior to that of the corresponding process on the left side. It is small, and its mammillary process is very feebly indicated. Its articular surface is flattened instead of being concave, and is of much greater extent than that on the right inferior articular process of L. 2, with which it articulates.

From the great disproportion between the relative extents of their articular surfaces, it may be presumed that, in spite of their dwarfing, the play of movement between the articular processes on the right side of L. 2 and L. 3 was unusually extensive.

The right inferior articular process is dwarfed more conspicuously even than in the case of the corresponding process on L. 2. Its articular surface is very small, somewhat concave, and directed backwards, with a slight inclination outwards.

The vertebra is definitely asymmetrical when viewed from above. The neural arch seems to be tilted leftwards, but this distortion is probably more apparent than real. The apparent distortion is exaggerated by the unequal development of the articular processes and by the difference in set of the two lateral processes. The right lateral process is deflected obliquely backwards to a degree considerably greater than that of the left process; further, it has a decided kink or bend which opens backwards.

The body being thicker on the left side than it is on the right exhibits the form of a lateral wedge and in this respect resembles L. 1 and L. 2.

Lumbar 4 has, like L 3, a neural arch incomplete on the right side. It presents a contrast to L. 3 in that the interruption is a slit-like interval in front of the superior articular process. The difference between the two vertebræ may be expressed by saying that in L. 3 the superior articular process is carried by the pedicle and has no direct association with the lamina, while in L. 4 the superior articular process is carried by the lamina and has no direct association with the pedicle.

The articular processes present anomalous features. The left superior articular process is normal, but the right superior articular process is short and stumpy; it

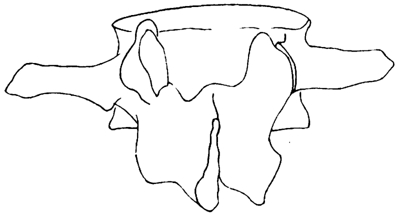


FIG. 9.—Lumbar 4 viewed from behind. Note the interruption in the neural arch on the right side, and the dwarfing of the articular process on the right side above, on the left side below.

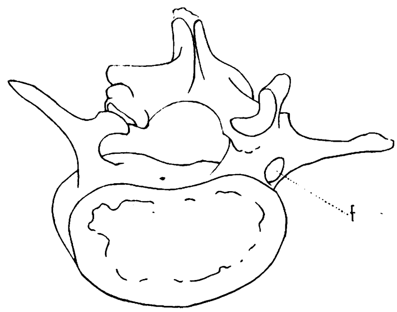


FIG. 10.—Lumbar 4 viewed from above. Note the position of the interruption ventral to the dwarfed right superior articular process; *f*, large foramen traversing left pedicle.

presents a narrow vertically elongated articular surface directed forwards and slightly inwards.

A disproportion between the articular surface in this process and that in the process of L. 3, with which it articulates, is again to be noticed. Similar conclusions as to the potential mobility during life between L. 4 and L. 3 may be drawn as held good for L. 3 and L. 2 (*q.v.*).

The two inferior articular processes present a remarkable contrast to the two superior. The right inferior process is normal, while the left inferior process is partially aborted, and its articular surface is not well defined. The alternate development of the articular processes above and below bestows a marked asymmetry on the appearance of the vertebra when viewed from behind. The vertical bar which terminates above and below in the articular processes is at a lower level on the right side than it is on the left.

The two lateral processes exhibit a contrast to one another comparable to the condition in L. 3. The right process is deflected obliquely backwards to a much greater extent than is the left process. Occupying the fore part of the root of the left lateral process is a large rounded foramen (*vide* fig. 10).

The presence of this foramen may indicate the partial independence of a costal element.

The neural arch is more definitely asymmetrical than is that of L. 3. The left pedicle is about double as thick as the right pedicle. The neural arch seems to be tilted very decidedly leftwards on the body; but the spinous process, though broken and incomplete, is deflected in the opposite direction, *i.e.* rightwards.

The body is thicker on the right side than it is on the left, *i.e.* it is wedge-shaped, with the base of the wedge facing rightwards.

Lumbar 5 is remarkable in having a greater lack of continuity in the neural arch than is found in either L. 3 or L. 4. The neural arch presents two interruptions. One interruption occurs behind the root of the left superior articular process; the other at the dorsal end of the right lamina, where it abuts upon the spinous process. As the two interruptions are complete, the left lamina, carrying the left inferior articular process and the spinous process, constitutes an ossicle independent of the rest of the vertebra. The contact surfaces of the ossicle and of the main part of the vertebra are smooth, and were evidently cartilage clad in the recent state. This indicates that the nature of the junctions between the two was articular, and that the ossicle was capable of relative displacement on the main part of the vertebra.

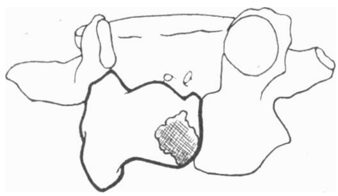


FIG. 11.—Lumbar 5 viewed from behind. The detached element is indicated in heavy outline. The shaded area represents the stump of the spinous process.

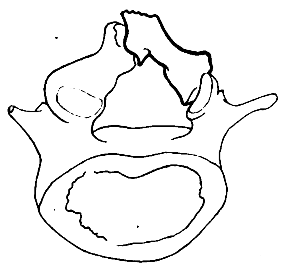


FIG. 12.—Lumbar 5 viewed from above. The detached part consisting of the left lamina and broken-off stump of the spinous process is indicated in heavy outline.

The articular processes may be said to be the converse of those found in L. 4. The right superior process is normal, while the left superior process is stunted, and presents an indefinite articular surface directed inwards. On the other hand, the left inferior process is normal, while the right inferior process can scarcely be said to exist, its articular surface, which is small and trochleoid, mainly involving the lamina. From the disposition of the articular processes it follows that the vertical bar carrying the superior and inferior processes is at a higher level on the right side than it is on the left. (*Cf.* L. 4, where the converse holds good.)

When viewed from above, the vertebra is seen to be asymmetrical. The asymmetry is due mainly to a leftward tilt of the neural arch on the body. The spinous process is broken off short, but there is evidence that it was deflected rightwards, thus neutralising to a certain extent the leftward tilt of the neural arch. (*Cf.* L. 4, where a similar disposition holds good.) The right pedicle is especially thick and strong, being roughly double the size of the left pedicle. (This feature is the converse of that found in L. 4.)

The body not only presents the normal wedge-like appearance, being much thicker in front than it is behind, but it is also a lateral wedge, the vertical depth on the right side being longer than the vertical depth on the left side. (In this respect it resembles L. 4, but presents a contrast to L. 1, L. 2, and L. 3.)

The bodies of all the lumbar vertebræ are wedge-shaped from two points of view: they present a fore and aft or sagittal wedge (the normal condition), and a side to side or coronal wedge (an anomalous condition). The extent to which the bodies of the five lumbar vertebræ present the features of a two-fold wedge was estimated by actual measurement. The results are shown in the following table:—

Vertical Depths of the Bodies of the Lumbar Vertebræ in Millimetres.

	In front.	Behind.	Right side.	Left side.
Lumbar 1 . .	25·5	26	25	25·5
,, 2 . .	26	26·5	25·5	26·5
,, 3 . .	27	26·5	25·5	26
,, 4 . .	26	25	26	24·5
,, 5 . .	27	23	27	26

From a consideration of the above it will be gathered that the bodies of L. 1, L. 2, and L. 3 are lateral wedges of such a form that the thicker ends or bases face leftward, while the bodies of L. 4 and L. 5 are lateral wedges whose bases face rightward.

In L. 3, L. 4, and L. 5 the bodies are thicker in front than behind, the condition being slightly marked in L. 3 and L. 4, and accentuated in L. 5. In L. 1 and L. 2 the converse obtains, as the bodies are thicker behind than in front, but only to a slight degree.

A lumbo-vertebral index may be obtained by

$$\frac{\text{sum of posterior vertical measurements} \times 100}{\text{sum of anterior vertical measurements}}.$$

The index 96 obtained in this instance is not a low one if compared with the indices obtained by Cunningham of 95·8, the average for seventy-six Europeans, and 93·5, the average for 22 Irish females. If the amount of the lumbar curve is to be estimated from the moulding of the bodies of the lumbar vertebræ, it was not accentuated in this young Egyptian female; but conclusions based on the shapes of the vertebral bodies alone, without taking the shapes of the intervertebral discs into consideration, are apt to be misleading.

Sacral Region.

The sacrum consists of six vertebræ. Of these the 1st exhibits partial independence, while the terminal results from the adherence of the 1st coccygeal vertebra.

Sacral 1, exhibits the not uncommon variation of partial detachment from the rest of the bone. The body of S. 1 is distinct from that of S. 2, and evidently an intervertebral disc of some appreciable thickness intervened between the two.

The partial independence of S. 1 is asymmetrical, being more obvious on the left side. The left lateral (costal?) process is short and stumpy, simulating the characteristics usually exhibited by that of L. 1. It is a free projection, and takes no share in forming the left lateral mass. The left inferior articular process is also free, not being synostosed with the corresponding process of S. 2. The right lateral process forms the upper part of the right lateral mass. It shows some tendency towards independence, as the upper part of the right lateral mass exhibits a ridge ending in a projecting tubercle, and which in position, obliquity, and appearance corresponds to the free lateral process on the left side.

The most remarkable feature in S. 1 is a double interruption in its neural arch of such a kind that the right lamina is an independent ossicle. The detached lamina has a dorsal tubercle which contributes to the spinous process. When the detached lamina is put into position this tubercle does not project dorsally to quite the same extent as the corresponding tubercle which surmounts the dorsal end of the left

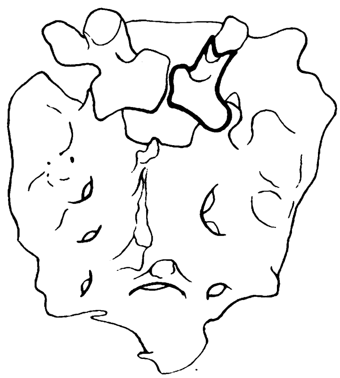


FIG. 13.—Sacrum viewed from behind. The detached part of the neural arch of sacral 1 is indicated in heavy outline.

lamina, but to all intents and purposes the cleavage plane between the right and left laminæ is median.

The condition is one which presents an interesting contrast to that existing in L. 5, where the detached lamina carries the spinous process *in toto*.

At the ventral (anterior) end of the detached lamina are two processes. Of these one is superior, and contributes to the formation of the right superior articular process; the other is inferior, and is obviously the right inferior articular process, in spite of the fact that it is smaller than the corresponding process on the left side. The detached lamina presents four smooth articular surfaces cartilage clad in the recent state:—(1) On the mesial aspect of the dorsal projection, which plays on the opposite component of the spinous process. (2) On the antero-lateral aspect of the superior process. This plays on the lower part of an extensive facet occupying the upper and larger portion of the right superior articular process carried by the right pedicle. (3) On the postero-lateral aspect of the superior process. This furnishes the lower part of an extensive articular surface on which the right inferior articular process of L. 5

plays. (4) On the antero-lateral aspect of the inferior process. This plays on the facet of the right superior articular process of S. 2.

The four articular surfaces of the detached lamina cannot be approximated simultaneously to the four surfaces on which they play. This feature, together with a disproportion in the relative extents of the opposed articular surfaces, furnish evidence that, during life, this detached part of the sacrum must have enjoyed a considerable mobility relative to the main part of the bone.

The articular surface of the right inferior articular process of L. 5, and of the composite socket provided for it by S. 1, are disproportionate: the latter is at least double the extent of the former.

From this it may be concluded that the potential displacement between L. 5 and S. 1 was considerable.

S. 1 not only exhibits a tendency to assimilate to a lumbar type by a partial independence, but in general configuration it suggests a lumbar vertebra rather than a sacral. The body is markedly concave from above downwards and convex from side to side, in contrast to the flattening which the ventral aspect of S. 1 usually exhibits. The body is so disposed on that of S. 2 as to suggest a sacro-vertebral angle: this angle is one of about 155°. Like that of L. 5, the body is decidedly wedge-shaped. The anterior vertical depth is 27 mm.; the posterior vertical depth is 22 mm. Consequently, it is much thicker in front than it is behind.

The 1st sacral vertebra, judging from its set on the rest of the sacrum and the wedge-like form, lumbar in type, of its body, must have taken some share in the conformation of the lumbar curve. If the measures of the anterior and posterior vertical depths of the body of S. 1 be added to those obtained for the lumbar vertebræ (*q.v.*), and a new lumbo-vertebral index be calculated from these additional data, it is found to be about 93. The result agrees very closely with the index of 93·5 obtained by Cunningham as the average index for twenty-two Irish females which he examined.

General Form of the Sacrum.

When viewed from in front the sacrum presents the usual concavity in a vertical plane, and this at first sight seems to be fairly well marked. The concavity, however, is mainly due to a sharp bend forward of S. 5, and its adherent coccygeal element at the lower end of the bone. The anterior surfaces of the bodies of L. 2, L. 3, and L. 4 are all uniformly flattened and disposed on the same plane. The extent of the sacral curvature is still further diminished by the set of the body of L. 1, which is disposed at an angle to the rest of the bone, and apparently takes a share in the lumbar curve (*vide supra*).

The sacrum as a whole is very asymmetrical. This asymmetry is not due solely to the greater bulk of the right lateral mass with which the lateral process of S. 1 is incorporated, while the left lateral process of S. 1 is discrete. It is also due to a lateral curvature involving the length of the bone. This curvature is concave rightwards, and is mainly dependent upon a decided rightward tilt, towards the lower end of the bone, of S. 4 and S. 5 with the fused coccygeal element. The vertebra the conformation of whose body decides the lateral curvature to a greater extent than any other is S. 4. When viewed from in front the body of S. 4 is very decidedly wedge-shaped, the vertical depth (10 mm.) on the right side being considerably less than that (16 mm.) on the left side. The vertical compression of the sacral vertebræ on the concave side (right) of the lateral curve is evidenced, not only by the shapes of the bodies, but also to a certain extent by the lateral sacral elements. The 3rd and 4th anterior sacral foramina on the right side are so closely approximated that the horizontal bar of bone which intervenes between them fails to reach the front of the bone, and the two foramina open into a common fossa (*vide* fig. 14). On viewing the bone from behind, the posterior sacral foramina present an interesting contrast to those in front. On this aspect the 2nd and 3rd foramina open in common, while

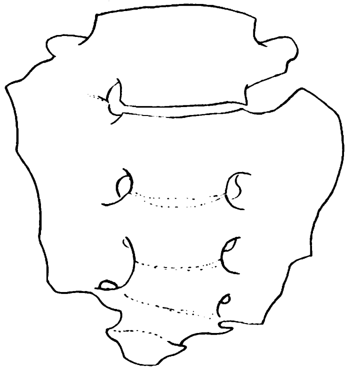


FIG. 14.—Sacrum viewed from in front.

the 4th is independent (*vide* fig. 13). The partially fused S. 1 does not take a share in the general lateral curvature in which the sacrum is involved. Its body certainly presents the form of a lateral wedge, but being thicker on the right side (27 mm.) than it is on the left (25 mm.), the base of the wedge is directed to the same side as the concavity of the lateral curve, and, to a certain extent, neutralises it.

The lateral aspects of the sacrum exhibit well-marked auricular facets on either side. The auricular facet does not extend above the limits of S. 2, even in the right, where S. 1 contributes to the formation of the lateral mass. The upper part of each lateral sacral mass exhibits a sharp sweep forwards, and suggests that the pelvic brim was more or less circular in outline.

From the probability of the pelvic line being circular in outline, and from the ventral flattening exhibited by S. 2, S. 3, and S. 4, a guess may be hazarded that the pelvis was of an infantile type.

Coccygeal Region.

Unfortunately coccygeal vertebræ, with the exception of the first, which is fused on to the sacrum, are absent.

General Conclusions.

This remarkable vertebral column presents such a wealth of anomalous features that it is a matter of some considerable difficulty to draw general conclusions as to their morphological value, or to decide upon any definite system of critical analysis.

The numerical ratios of the different regions, the synostosis of vertebral segments in the cervical region, the irregularity in form evinced in the lumbar region, and the interruptions in continuity of individual vertebræ in the cervical, lumbar, and sacral regions are all striking features, and will now be discussed *seriatim*.

Numerical Deviation.

One of the most remarkable features of this Egyptian spine is the presence of eight cervical vertebræ, or at least eight vertebræ exhibiting cervical characters. The 8th vertebra presents a detached costal process or free rib, and it might be argued that it was a thoracic vertebra exhibiting cervical characteristics. The balance of evidence, however, is in favour of the converse explanation that it is a cervical vertebra simulating thoracic conditions. Its general form as regards the shape of the body, the set of the articular processes, the disposition of the lateral processes on the left side, are all and preponderating cervical attributes.

The cervical region in man exhibits the general mammalian characteristic of remarkable numerical constancy. Variations in the direction of deficiency are not unfrequently met with in man if a 7th cervical vertebra with detached costal process or processes be relegated to the thoracic series. The presence of detached costal processes or free ribs, however, is not evidence sufficient to divorce a vertebra *in toto* from the cervical region.

Variations in the direction of cervical excess are exceedingly rare. In 1895 Leboucq recorded two examples of additional cervical vertebræ. Previously to Leboucq, this rare condition has only been recorded by Lane, Leveling, and Wallmann, and in some of these instances the cervical excess is to be accounted for by the 1st thoracic vertebra evincing cervical characteristics, the 1st rib being rudimentary. Leboucq describes the additional vertebra as C. 3, which, in both the cases he records, was fused to the axis. It is an interesting and suggestive corollary that in this Egyptian skeleton the axis and the succeeding vertebra are represented by a composite mass.

The explanation of regional numerical deviation in the human spine is a difficult and complex problem.

The explanation more generally accepted may be defined as the compensation theory. It assumes that a more or less fixed homology exists between the individual vertebræ of all spines; that the form value of any vertebra is not absolute, it may assimilate to a greater or less extent to a neighbouring vertebra; variation in form value may lead to numerical reduction or increase in one region, compensated for by numerical increase or reduction in adjoining region or regions.

Rosenberg, and, previously to him, Regalia, seek the explanation of numerical variation in presacral vertebræ in the relative position of the pelvic girdle, which may presumably shift headwards or tailwards along the vertebral axis.

Taruffi accounts for numerical variation by referring it to an anomalous segmentation at an early stage, when the vertebral column is in a membranous condition. Leboucq proffers a somewhat similar solution, but refers the anomaly perhaps to a still earlier stage by suggesting that numerical variation in the direction of excess is due to fission of the primitive germ (*ébauche*) of a vertebra.

If, in Leboucq's cases and in this Egyptian skeleton, C. 3 is to be regarded as the additional cervical element, and if, as Leboucq suggests, it is due to a reduplication of C. 2 by fission of the vertebral germ belonging to the 2nd cervical segment at an early stage, it would be expected that the additional vertebra would recapitulate the features of the vertebral segment to which it properly belongs. In other words, the interpolated vertebra C. 3 should present features evincing a closer kinship to the axis than to the succeeding cervical vertebræ. In the cases which Leboucq describes, he states that this is the case, the incorporated vertebra recapitulating more or less completely the features of the axis. In the Egyptian skeleton a definite structural relationship between the axis and the vertebra with which it is fused is not so obvious. There is indeed an important contrast between them. The superior articular surfaces of the axis are as usual ventrally disposed to the site of emergence of the 2nd cervical nerve from the spinal canal. C. 3 exhibits a well-marked pedicle constituting the lower boundary of an intervertebral foramen between it and the axis, and a definite indication of a superior articular process behind the intervertebral foramen; in other words, its superior articular processes are dorsally disposed to the site of emergence of the 3rd cervical nerve. The relationship to the spinal nerves is as good a differential feature as any, and in this important respect C. 3 evinces a closer kinship to C. 4 than to the axis. Further, as the 1st ribs are preserved and they present the normal grooves, the hinder of which, as Wood Jones has proved, is a nerve impression, and as all the intervertebral foramina on the cephalic side of the vertebra in association with these typical 1st ribs are present and well formed, it may be assumed that nine pairs of cervical nerves co-existed with the vertebral anomaly. The condition is obviously one of profound segmental variation, of which the additional cervical vertebra is only a limited expression, and fission of a vertebral germ at an early stage is not an adequate or satisfactory explanation.

The numerical condition of the cervical region must not be considered *per se*, but must be considered in association with the rest of the vertebral column. Co-existing with the eight cervical vertebræ are twelve thoracic, and these vertebræ, if the conditions of the costal facets may be taken as evidence, were all provided with well-developed ribs. Unfortunately, only four ribs have been preserved, but amongst these is the 1st pair, which present normal features and complete the evidence that the 1st thoracic vertebra is of the average human type. The lumbar region is numerically complete. Included in the sacral region, and only included therein because it is inseparable, is a vertebra which in other respects is more lumbarised than sacralised. In this Egyptian spine the vertebra fulcralis (Welcker) is the 27th, and not the 25th, the normal human condition. The spine, therefore, presents twenty-six presacral vertebræ, or perhaps it would be safer to say that the condition of twenty-six presacral vertebræ is nearly attained.

The condition of twenty-six presacral vertebræ is rare. It has been described by Dwight, Rosenberg, and others; but in their cases the excess was definitely thoracico-lumbar, thirteen thoracic vertebræ existing with six lumbar, the 1st thoracic vertebra bearing ribs which exhibited normal features.

A spine to which the formula C. 8, Th. 12, L. 6, may be ascribed has, as far as I know, never been recorded before.

Applying the hypothesis of a relative shifting of the pelvic girdle on the vertebral axis to a condition of twenty-six presacral vertebræ, it would be explained by assuming that the pelvic girdle had shifted caudalwards to such an extent as to make the 27th vertebra the vertebra fulcralis, instead of the 25th. In Dwight's and Rosenberg's cases this shift apparently affects the thoracico-lumbar region in such a way that two sacral vertebræ have become lumbarised and absorbed into the lumbar region, and the normal 1st lumbar, acquiring free ribs, has assimilated to the thoracic type. The shifting has influenced a limited region of the spine, and a region neighbouring closely the pelvic girdle.

If the twenty-six presacral vertebræ of the Egyptian spine are to be explained by a shifting of the pelvic girdle relative to the vertebral axis, it must be assumed that not only have two sacral vertebræ become lumbarised and the normal 1st lumbar assimilated to a thoracic type, but that the whole of the thoracic region has been affected to such a profound extent that the normal 2nd thoracic vertebra has acquired the characteristics of a 1st thoracic vertebra completely, and that the normal 1st thoracic vertebra has been cervicalised in almost every detail. Such extensive and far-reaching influence of a pelvic shift is incredible: the explanation is too bizarre to be considered seriously.

Bateson insists that two forms of meristic variation are to be recognised: true meristic variation, or variation in the total number of segments, as instanced by a numerical variation of the total number of vertebræ comprised in a vertebral column; and homoœtic variation, in which there is no numerical variation as regards the total number of segments, but the number or ordinal position of the vertebræ in any one region are affected by a deviation which is compensated for by excess or diminution, as the case may be, in a neighbouring region. Bateson admits that the two kinds of variation may be combined in one vertebral column, and it is impossible in many cases to distinguish between them. So far as I understand Bateson's definition of a true meristic variation, it implies anomalous segmentation at its very earliest stage either in the direction of superaddition or subtraction, or such a shifting of primitive segmental planes as to result in a rearrangement of consecutive parts. Bateson instances one case only of true meristic variation in the human spine, viz. the presence of an additional coccygeal vertebra, the other regions being complete. A diminution or excess in the coccygeal region, however, does not necessarily imply a deviation from normal segmentation. There is evidence to show that at an early stage, even as late as the chondrification stage, the coccygeal vertebræ are more numerous than they are when bony consolidation is complete, and that the numerical reduction which eventually ensues is the result of secondary fusion. One bony coccygeal vertebra may represent potentially two or more vertebral segments. Diminution or excess in the coccygeal region admits of the simple explanation of diminished or excessive fusion, without appealing to deviation from normal segmentation as the determining factor.

Bateson supplies us with the useful terms forward homoœsis and backward homoœsis. Forward homoœsis implies a form deviation in a vertebra which assumes characters typical of the region on the cephalic side of that to which it belongs, backward homoœsis if it assumes the characters typical of the region on the caudal side of that to which it belongs. Forward homoœsis is instanced by a 1st lumbar vertebra provided with ribs, backward homoœsis by a 7th cervical vertebra provided with ribs.

The key to the solution of the condition in the cervical region of the Egyptian spine is possibly the interpretation of the 8th vertebra. Is it to be regarded as a case of forward homoœsis or of backward homoœsis? If vertebra 8 exhibits forward homoœtic deviation, vertebræ 1 to 7 comprise the cervical series, and Th. 1 has acquired cervical attributes to an extent which has not been met with in any human spine yet recorded. Further, the forward homoœsis has affected Th. 2 so profoundly that it has assumed completely, both as regards vertebra and rib, the features normally exhibited by Th. 1: a condition of Th. 2 to which I submit there is no parallel.

Taking the form stability of Th. 1 in contrast to the relative form instability of C. 7 in man into consideration, a backward homoœsis is a much more acceptable explanation of the condition evinced by vertebra 8. Backward homoœsis implies that the vertebra associated with the typical 1st ribs is the representative of the 1st thoracic vertebra as it is found in the average human spine, and vertebra 8 is a cervical vertebra which has assimilated to a thoracic type, but not in any marked degree.

Keeping in view Bateson's warning that there is not necessarily an absolute correspondence between the vertebræ of any two spines, even if there be numerical agreement, and recognising that although variation of the vertebræ goes hand in hand with variation of the segmental (spinal) nerves, yet the correlation between the two is not exact, I suggest that the most satisfactory explanation of the numerical deviation evinced by the cervico-thoracic region of this Egyptian spine is an anomaly of primitive segmentation in the cervical region: a true meristic variation somewhat complicated by backward homoœsis, but which affected both the skeleton and the soft parts of the neck.

Synostosis of Vertebral Segments in the Cervical Region.

Occipito-atlantal fusion has been so frequently described and discussed that it needs no further comment here. I will only call attention to the asymmetrical position of the fused atlas relative to the skull, an asymmetry previously noted by Dwight. The Museum of Human Anatomy at Cambridge possesses six specimens of occipito-atlantal fusion, and in five of them asymmetry of the atlas relative to the occipital bone is indicated. In one the median tubercle on the anterior arch of the atlas is deflected very slightly leftwards, and in four it is deflected more or less decidedly rightwards. The Egyptian spine agrees with the majority of the specimens in our museum in that the median tubercle of the anterior arch of the atlas is deflected rightwards. General conclusions cannot be drawn from such a limited amount of material, but occipito-atlantal fusion seems to be associated with asymmetry in disposition of the atlas relative to the skull, and the asymmetry is usually a comprehensive axial rotation leftwards of the atlantal ring on the occipital bone.

The fusion between axis and C. 3 in association with numerical excess in the cervical region has already been noted (p. 161).

The Irregularity in Form of the Individual Vertebræ as Evidence of Spinal Deformity.

It can scarcely be doubted that the girl of whose skeleton this vertebral column is a part was the victim of more or less pronounced spinal deformity. Anyone, examining the 4th lumbar vertebra with, amongst other features, its distorted neural arch, the lateral wedge shape of its body, the backward inclination of its right lateral process, and its deflected spinous process, would have little hesitation in pronouncing it as belonging to a subject who had been the victim of severe and permanent lateral curvature (scoliosis) during life.

The extent and nature of the lateral curvatures which possibly affected this spine may perhaps be best estimated by the shapes of the vertebral bodies, in so far as they present the appearance of lateral wedges. From this criterion it may be assumed that the lateral curvatures were confined to the cervical, lumbar, and sacral regions, the thoracic region being to all intents and purposes normal.

In the cervical region two curves are indicated. They are both very short and involve the first three and possibly the 4th cervical vertebra. The upper curve is concave leftwards, the lower curve concave rightwards. Such slight curvatures would not account for any very obvious deformity in the neck region. The lower curve is obviously a compensation curve neutralising the asymmetrical occipito-atlantal fusion.

In the lumbo-sacral region three curves are indicated. The upper, involving L. 1 to L. 3, is concave rightwards; the intermediate, involving L. 4 to S. 1, is concave leftwards; and the lower, involving the rest of the sacrum and the coccyx, is concave rightwards.

Such a succession of short curves I have never seen exampled in the scoliotic spines which I have had the opportunity of examining, and I can find no record of a like condition.

The lateral curvature of the sacrum is remarkable, as the sacrum rarely takes a share in the spinal deformity which occurs in scoliosis, even in cases where the condition is of a very severe type.

The distortions which the individual vertebræ of a scoliotic spine evince are fully described in the works of Adams, Barwell, Bradford and Lovett, Tubby, etc. The anomalous features may be summarised as follows :—

On the concave side of the spinal curve the body is shortened sagittally and its vertical depth diminished; the pedicle is relatively thin, obliquely disposed, and may present actual deficiency; the articular processes are stunted; the lamina is long and narrow.

On the convex side of the spinal curve the body is lengthened sagittally and its vertical depth increased; the pedicle is thick and directed sagittally; the lamina is short and broad; the spinous process is deflected towards this (the convex) side.

How far the lumbar vertebræ of the Egyptian spine fulfil the conditions typical of a scoliotic vertebra may perhaps be estimated most conveniently by summarising the several features exhibited on the concave and convex

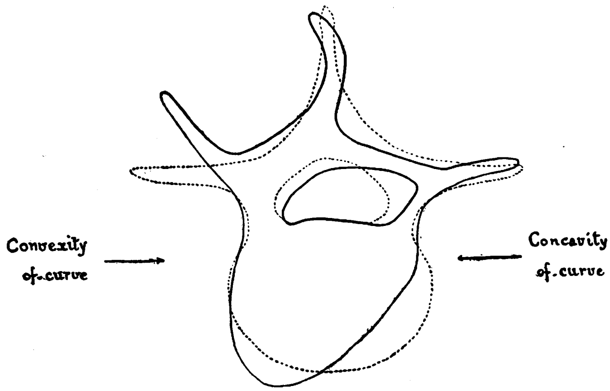


FIG. 15.—Diagrammatic scheme of the features typical of a scoliotic vertebra (continuous outline) superimposed on a normal vertebra (dotted outline).

sides of the curve respectively, in so far as they are illustrated in each individual vertebra.

If the symbol **V** be used to indicate a feature found on that side of a scoliotic vertebra which faces the concavity of the curve, and **X** a feature on the opposite side, *i.e.* facing the convexity of the curve, scoliotic features, as far as they can be recognised in the lumbar vertebræ of the Egyptian spine, may be summarised as follows:—

On concave side:
- V^1 vertical depth of body shortened.
- V^2 articular process stunted.
- V^3 deficiency in neural arch, partial or complete.

On convex side:
- X^1 pedicle hypertrophied.
- X^2 spinous process deflected towards this side.
- X^3 lateral process deflected backwards.

The lumbar vertebræ of the Egyptian spine may now be tabulated as follows:—

	Right side.	Left side.
Lumbar I .	V^1 X^3 (slight).	
,, II .	V^1 V^2 X^1 (slight) X^3.	
,, III .	V^1 V^2 X^2 X^3.	V^3 X^1.
,, IV .	V^2 (above) X^2 X^3.	V^1 V^2 (below) V^3 X^1.
,, V .	V^2 (below) X^1 X^2 X^3.	V^1 V^2 (above) V^3.

An examination of this table shows pretty clearly a preponderance of typical features on the one side or the other as regards lumbar IV and lumbar V and suggests a lateral curvature with a leftward concavity. As a whole, however, the evidence is too conflicting, especially as regards lumbar II and lumbar III, to be of much value in determining the nature and extent of a lateral spinal curve.

Further, certain important scoliotic features, such as asymmetry of the body of the vertebra when viewed from above or below, attenuation or increase in vertical depth of the lamina, have not been taken into account, as of such features there is little or no trace.

The absence of such features and the general confusion of features simulating scoliosis may be taken as fairly conclusive evidence that if spinal deformity existed in the lumbar region it was not of an ordinary or recognisable type.

Interruptions in the Continuity of Individual Vertebræ.

The vertebral column exhibits a truly remarkable series of interruptions in the continuity of the individual vertebræ. No less than five vertebræ, viz. C. 7, L. 3, L. 4, L. 5, and S. 1 have partially deficient neural arches.

In C. 7 the deficiency is dorsi-median, a condition which has been frequently recorded, and may probably be explained by the laminar processes of the two neural arches failing to unite at an early stage and while still in a cartilaginous condition.

The deficiencies in the lumbo-sacral region present certain interesting features.

In L. 3 the interruption is on the right side and is dorsal to the superior articular process, the right pedicle carrying both the lateral process and the superior articular process.

In L. 4 the interruption is again on the right side, but ventral to the superior articular process, the right pedicle carrying the lateral process only.

In L. 5 the interruption is double, one on the right side at the junction of lamina and spinous process, the other on the left side dorsal to the superior articular process. The result of the two interruptions is an independent ossicle consisting mainly of the left lamina and carrying the left inferior articular process.

In S. 1 the interruption is again double, but the interruptions are both on the same side. One subdivides the spinous process; the other interrupts the continuity of the right superior articular process. The result of the two interruptions is an independent ossicle consisting mainly of the right lamina and carrying a part of the spinous process, the right inferior articular process, and a part of the right superior articular process.

Summarising the conditions exhibited by these vertebræ, it will be gathered that they exemplify almost every conceivable form of interruption in the continuity of the neural arch.

Ventral to the superior articular process (L. 4).

In the superior articular process itself (S. 1).

Dorsal to the superior articular process (L. 3, L. 5).

At junction of lamina and spinous process (L. 5).

In the spinous process itself (S. 1).

It must be granted that such a wide range in position of the interruptions in the neural arches admits of no satisfactory morphological interpretation.

Poirier supports Neugebauer's view that spondyloschisis, or interruption in an individual vertebra, may have an explanation other than a morphological one and may be due to traumatism. I take it that Poirier uses the term traumatism in a wide sense, does not insist that the interruption occurred suddenly, and allows that the interruption may appear as a gradual response to mechanical usage. From the fact that in this Egyptian spine the spondyloschisis is limited to a region which is particularly adapted to extensive movements, excessive mechanical usage may have been the determining factor.

Whatever the prime cause of the spondyloschisis may have been, the condition is consonant with a wider range or movement in the lumbar region during life than occurs in a normal individual. That the lumbar was probably a region of excessive mobility is borne out by the conditions of the articular processes. The dwarfed articular processes I took at first to imply a condition of reduced mobility, but careful examination of these processes brings out the fact that, judged by the great disproportion existing between their opposed articular surfaces, the amount of play between them must have been very considerable during life.

The dwarfed articular processes and the interruptions in the neural arches seem to be associated. Both tend to occur on the same side in the individual vertebra, although they affect the two sides of the spine alternately—the right side in L. 3 and L. 4, the left side in L. 5, and the right side in S. 1.

This association is fairly conclusive evidence that both features are structural responses to a common determining factor. That this factor was excessive mechanical usage is the simplest explanation.

Further, and to a certain extent confirmatory evidence that the lumbar region of the spine was adapted to excessive movement, is afforded by the conditions exhibited by the adjoining thoracic and lumbar regions. The joints between the 11th and 12th thoracic vertebræ are partially lumbar in type. From this it may be concluded that the relative displacements which took place between the 11th and 12th thoracic vertebræ were displacements associated with flexion, extension, and lateral bending of the trunk, in contradistinction to the rotatory movement about a vertical axis, for which the thoracic vertebræ are more particularly adapted. Such displacements taking place between the 11th and 12th thoracic vertebræ would add, if only in a small degree, to the scope of movement in the lumbar region. The relationship of the 1st sacral vertebra relative to the 1st lumbar vertebra, its very partial incorporation with the rest of the sacrum, its freely movable right lamina and the peculiar set of its body suggesting a caudal prolongation of the lumbar curve, can all be taken as evidence that this vertebra was adapted to play a subsidiary part in the movements peculiar to the lumbar region. Indeed, it is conceivable that the lumbarised conditions of the 1st sacral vertebra is itself a response to mechanical usage, more especially if this Egyptian girl indulged in excessive trunk movements at an early age.

Evidence, gleaned from the thoracic and cervical regions, suggesting that the spine as a whole was especially adapted to trunk movements, is not so convincing. Attention, however, may be called again to the peculiar costal facets in the thoracic vertebræ which were indicative of very free play of the vertebral ends of the ribs.

A careful analysis of the articular features in the cervical region shows that the reduced mobility which would of necessity result from vertebral fusions was at least fully neutralised by the secondary articular modifications with which these fusions are associated.

It may not be very wide of the mark to conclude that this spine evinces marked reaction to prolonged and excessive usage, that this excessive usage commenced at a fairly early stage of life, and that the possessor was a contortionist.

This Egyptian girl, whose bones preserved by the burning sands of the desert live yet to tell their tale, may have delighted Ptolemaic audiences as an expert exponent of the acrobatic art.

[*Note.*—On reading Dr Barclay-Smith's conclusions I was reminded of the figures of female acrobats which I had seen in a tomb at Beni-hassan. Two of these, which show extreme forms of spinal contortion, are represented in the outlines appended.—A. M.]