CHAPTER III.

LINEAR SERIES—*continued.*

VERTEBRÆ AND RIBS.

THE Meristic Variations of the vertebral column constitute a subject of some complexity. In considering them it must be remembered that numerical change may be brought about in the series of vertebræ by two different processes: first, by Variation in the total number of segments composing the whole column, in which case the variation is truly Meristic; and secondly by Variation in the number or ordinal position of the vertebræ comprised in one or more regions of the column, not necessarily involving change in the total number of segments forming the whole series, and in this case the variation is Homœotic. Though Homœotic Variation is often associated with change in the total number of segments, from the nature of the case it is rarely possible in any given instance to distinguish clearly whether such change has occurred or not. This arises largely from the fact that while to find the total number of vertebræ it is necessary to know the exact number of caudal vertebræ, in many specimens these are incomplete, and even if present their number cannot often be given with confidence. For these reasons the chief interest of this section of the facts arises in connexion with Homœotic Variation, and the modes in which it occurs; but it must be constantly borne in mind that in almost any given case there may be Meristic Variation also, though the evidence of this may be obscured.

TRUE MERISTIC VARIATION IN VERTEBRÆ AND RIBS.

I. *Vertebræ.*

True Meristic Variation, that is to say, change in the total number of segments composing the whole column, may nevertheless be plainly recognized in certain animals. Among some of the

lower vertebrates, Fishes and Snakes, for example, the range of such Variation may be very great. Among Mammals the following may be given as an example of considerable Variation in the number of præsacral vertebræ in a wild animal, and such evidence may be multiplied indefinitely.

5. **Erinaceus europæus** (the Hedgehog).

	C	*D*	*L*	*S*	*C*	Total
No. 1	7	14	6	4	11	42
2	7	15	6	3	10+	
3	7	16	6	3	9+	
4	7	15	6	4	12	44
5	7	15	6	4	11	43
6	7	14	6	3	9+	
7	7	15	6	3	11 or 12	
8	7	15	6	3	13	44
9	7	15	6	3	12 or 13	

Nos. 1—5 in Mus. Coll. Surg., see *Catalogue*, 1884, pp. 645 and 646; No. 6 in Cambridge Univ. Mus.; Nos. 7—9 in British Museum.

6. **Man.** The simplest form of true Meristic Variation in the total number of vertebræ may occur in Man by the formation of an extra coccygeal vertebra, making five coccygeals in addition to five sacrals, *i.e.* ten pelvic vertebræ in all. Instances of this are rare (STRUTHERS), though in many tailed forms such Variation is common. Two cases, in both of which the sixth piece (1st coccygeal) was partially ankylosed to the sacrum, are fully described by STRUTHERS, J., *Journ. Anat. Phys.*, 1875, pp. 93—96.

In the presence of cases like that last given, there is a strong suggestion that the number of vertebræ has been increased by simple addition of a new segment behind, after the fashion of a growing worm: the variation of vertebræ thus seems a simple thing. But there is evidence of other kinds which plainly shews this view of the matter to be quite inadequate. Some of these facts may now be offered, and in them we meet a class of fact which will again and again recur in other parts of the study of Repeated Parts.

IMPERFECT DIVISION OF VERTEBRÆ.

*7. **Python tigris**[1]. This is a case of great importance as illustrating several phenomena of Meristic Division. In a skeleton of *Python* in the *Mus. Coll. Surg.*, No. 602, the following peculiarities of structure are to be seen. Up to the 147th inclusive the vertebræ are normal, each having a pair of transverse processes and a

[1] This and the following cases of *Pelamis* and *Cimoliasaurus* are discussed by BAUR, G., *Jour. of Morph.*, IV. 1891, p. 333.

pair of ribs. The appearance of the next vertebra is shewn in the figure (Fig. 10, I.). Anteriorly, and as far as the level of the posterior surface of the transverse processes, it is normal, save that its neural spine is rather small from before backwards. The transverse processes bear a pair of normal ribs. But behind this pair of transverse processes the parts, so to speak, begin again, rising again into a neural spine, and growing outwards into a second pair of transverse processes, with a second pair of normal ribs. Posteriorly again the parts are normal. This specimen is described in the *Catalogue* of 1853, as "148th and 149th vertebræ ankylosed," but upon a little reflexion it will be seen that this account misses the essential point. For the bone is not two vertebræ simply joined together as bones may be after inflammation or the like, but it is two vertebræ whose *adjacent parts are not formed*,

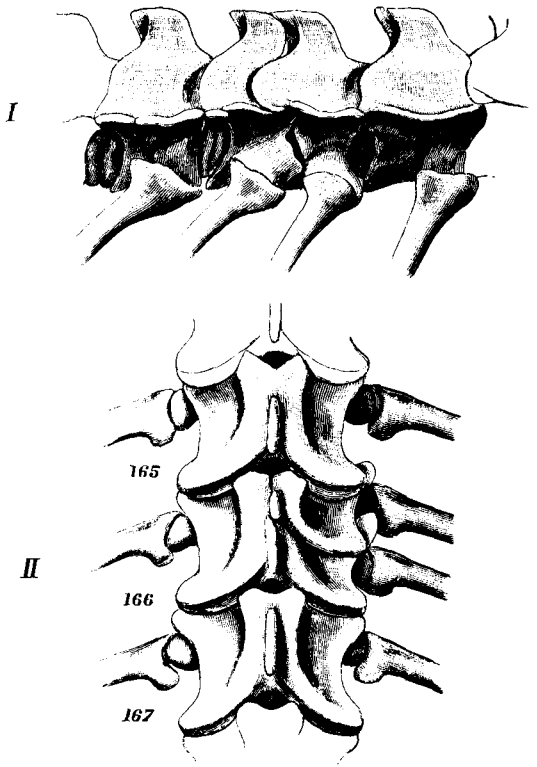

FIG. 10. Two examples of imperfect division of vertebræ in one specimen of *Python tigris*. I. The vertebræ 147—150 seen from the right side, shewing the imperfect division between the 148th and 149th. The condition on the left side is the same. II. View of dorsal surface of vertebræ 165—167, shewing duplicity of 166th vertebra on the right side. On this side it bears two ribs. The left side is normal. (From a skeleton, in Coll. Surg. Mus., No. 602.)

and between which the process of Division has been imperfect. With more reason it may be spoken of as one vertebra partly divided into two, but this description also scarcely recognizes the real nature of the phenomenon.

Further on, in the same specimen, at the 166th vertebra, there is an even more interesting variation. This vertebra is represented in Fig. 10, II. As there seen, it is normal on the left side, bearing one transverse process and one rib, while on the right side there are *two* complete transverse processes and *two* ribs. The 185th vertebra is also in exactly the same condition, being double on the right side and single on the left.

8. **Python sebæ :** a precisely similar case (Brussels Museum, No. 87, I. G.), in which the 195th vertebra is single on the right side and double with two ribs on the left, is described by ALBRECHT, P., *Bull. Mus. Nat. Hist. Belg.*, 1883, II. p. 21, Plate II.

9. **Python** sp.: a precisely similar case of duplicity in the 168th vertebra, on the left side, in a mounted skeleton in the *Camb. Univ. Mus.*

It is to be especially noticed that in each of these four cases of lateral duplicity, the degree to which the process of reduplication has gone on is the same.

10. **Pelamis bicolor** [= *Hydrophis*]. The 212th vertebra simple on the left side, and double on the right. It bears one rib on the left side and two ribs on the right side. *Yale Univ. Mus.*, No. 763. BAUR, G., *Jour. of Morph.*, IV. 1891, p. 333.

11. **Cimoliasaurus plicatus** (a Plesiosaur). "Centrum of a small and malformed cervical vertebra from the Oxford Clay near Oxford. This specimen is immature, and on one side is divided into two portions, each with its distinct costal facet." LYDEKKER, R., *Cat. Fossil Rept. and Amph. in Brit. Mus.*, Pt. II. 1889, p. 238, No. 48,001.

A case somewhat similar to the above is recorded in the Rabbit by BLAND SUTTON, *Trans. Path. Soc.*, XLI., 1890, p. 341. See also certain cases of a somewhat comparable variation in Man, considered in connexion with the variations of Bilateral Series.

II. *Ribs.*

12. **Man.** Partial division of ribs is more common than that of vertebræ. Five cases are given by STRUTHERS. 1. Fourth rib becoming broad, and bifurcated in front. Male, aged 93. From about middle of shaft these ribs gradually increase in length from 7 lines to $1\frac{1}{2}$ inch on the left side, $1\frac{1}{4}$ on right. They then fork, the left $1\frac{1}{4}$ inch, the right $\frac{1}{4}$ inch from where they join their cartilages. Cartilage of right forks close to rib, enclosing a space which admits little finger; cartilage of left lost, but the diverging bony divisions, each of good breadth for a rib (6 to 7 lines) enclose an intercostal space $1\frac{1}{2}$ inch long, attaining a breadth of $\frac{3}{4}$ inch, which was probably continued forwards by the division of the

cartilage or by two cartilages. The cartilage of the left 7th rib is also double for 1½ inch, all the others are normal. 2. Left fourth rib becoming very broad and bifurcating in front; two large spaces, one in the bone, one at the bifurcation. 3. Left fourth rib becoming broad towards sternal end, where it joins bifurcated cartilage. In these three cases the division affected the 4th rib. Three others are given in which the rib affected was probably the 4th or 5th. STRUTHERS, J., *Jour. Anat. Phys.*, Ser. 2, VIII. 1875, p. 51. Such cases are often recorded and preparations illustrating them may be seen in most museums.

Besides these cases of obviously Meristic Variation, there are many which are combined with Homœosis so as to produce far greater anatomical divergence. Though in some of these examples there may be change in the total number of vertebræ shewing that true Meristic change has occurred, they cannot well be treated apart from the more distinctly Homœotic cases.

HOMŒOTIC VARIATION IN VERTEBRÆ AND RIBS.

Homœosis in vertebræ may be best studied in Mammals, and the following account in the first instance relates chiefly to them. Before considering the details of such variations in vertebræ, it may be useful to describe briefly the ordinary system of nomenclature which is here followed. In treating this subject it is impossible to employ a terminology which does not seem to imply acceptance of the view that there is a true homology between the individual vertebræ of two spines containing different total numbers, for all the nomenclature of Comparative Anatomy is devised on this hypothesis. This difficulty is especially felt in regard to vertebræ, and at this point it should be expressly stated that in using the ordinary terms no such assent is intended. This matter has already been referred to in Section VI. of the Introduction, and will be discussed in relation to the facts to be given.

The vertebral column[1] is divided into five regions:—cervical, dorsal, lumbar, sacral and caudal. None of these regions can be absolutely defined, but the following features are generally used to differentiate them.

Cervical vertebræ are those of the anterior portion of the column, which either have no moveable ribs, or else have ribs which do not reach the sternum. *Dorsal* vertebræ are those which lie posterior to the cervicals and have moveable ribs. *Lumbar* vertebræ are those which succeed to the dorsals and have no moveable ribs. *Sacral* vertebræ cannot be defined in terms applicable even to the whole class of mammals, but, for the purpose of this consideration, it will be enough to use the term in the sense ordinarily given to it in human anatomy, to mean those vertebræ which are ankylosed together to form a sacrum. *Caudal* vertebræ are vertebræ posterior to the sacrum.

The characters thus defined are distributed among the several vertebræ according to their ordinal positions. Among mammals the number of vertebræ which develop the characters of each re-

[1] Abridged from FLOWER, W. H., *Mammals, Living and Extinct*, 1891, p. 41.

gion, though differing widely in different classificatory divisions, are as a rule maintained with some constancy within the limits of those divisions, which may be species, genera or larger groups, so that vertebral formulæ are often of diagnostic importance. Changes in the numbers of vertebræ composing the several regions must therefore have been an important factor in the evolution of the different forms.

Homœotic Variation in the spinal column consists in the assumption by one or more vertebræ of a structure which in the type is proper to vertebræ in a different ordinal position in the series. Examples of this are seen in the case of the development of ribs on a vertebra which by its ordinal position should be lumbar; or in the occurrence of a vertebra, normally lumbar, in the likeness of a sacral vertebra, having its transverse processes modified to support the pelvic girdle, &c. Variations of this kind have one character in common, which though at first sight obvious, will help us in interpreting certain other cases of Homœosis. In all cases of development of a vertebra normally belonging to one region, in the likeness of a vertebra of another region, this change always takes place in vertebræ adjacent to the region whose form is assumed. For example, if one vertebra, normally cervical, bears ribs, it is always the last cervical; if two cervicals bear ribs, they are the last two, and so on. No gaps are left.

Homœotic Variation in the spinal column may occur by the assumption of

(1) *dorsal* characters by a vertebra in the ordinal position of a *cervical*,

(2) *lumbar* characters by a vertebra in the ordinal position of a *dorsal*,

(3) *sacral* characters by a vertebra in the ordinal position of a *lumbar*,

(4) *coccygeal* characters by a vertebra in the ordinal position of a *sacral*,

or by the reverse of any of these. Since almost any of these changes may occur either alone or in conjunction with any of the others, it is not possible to group cases of such Homœosis under these heads, but the consideration of the more complex cases will be made easier if simple examples of each class are first described as seen in Man.

I. *Simple cases.*—**Man.**

(1) *Homœosis between cervical and dorsal vertebræ.*

(*a*) From cervical towards dorsal type.

The chief character distinguishing dorsal vertebræ is the possession of moveable ribs. This character may to a greater or less extent be assumed by cervicals.

*13. Cases of the development of ribs on the 6th cervical seem to be extremely rare. One is given by STRUTHERS in a young spine, æt. 4. The ribs were present as rudiments only, being the same on both sides in the 6th vertebra, and on the left side in the 7th. Each of these rib-elements was $\frac{5}{12}$ inch long. In the 6th the ribs rested on the body of the vertebra, but in the 7th the rib did not reach so far. Full details, *q. v.*, STRUTHERS, *J. Anat. Phys.*, 1875, p. 32.

Cervical ribs on the 7th vertebra are comparatively common, being sometimes moveable and sometimes fixed. The literature of this subject up to 1868 is fully analyzed by WENZEL GRUBER, *Mém. Ac. Sci. Pét.*, Ser. VII. T. XIII., 1869, No. 2, who refers to 76 cases of such ribs, occurring in 45 bodies, being all that were known to him in literature or seen by himself. In addition to these 12 cases are described (10 in detail) by STRUTHERS (*l. c.*). Some of the results of an analysis of these cases are important to the study of Variation.

Of 57 cases, the ribs were present on both sides in 42 cases and on one side only in 15.

According to the degree of completeness with which the cervical ribs are developed, GRUBER divided them into four classes[1].

1. *Lowest development.* Cervical rib not reaching beyond the transverse process; corresponding to the vertebral end of a true rib with *capitulum* and *tuberculum*, and articulating by both of them. *Rare form.*

2. *Higher development.* Cervical rib reaching beyond the transverse process for a greater or less extent, either ending freely or joining with the first true rib. *Commonest form.*

3. *Still higher development.* Cervical rib reaching still further, and joining the cartilage of the first true rib either by its cartilaginous end or by a ligament continued from this. *Rarest form.*

4. *Complete development.* Cervical rib resembling a true rib, having a cartilage (generally for a greater or less part of its length united with the cartilage of the first true rib) connecting it with the sternum. *Less rare form.*

Gruber states, as the result of an analysis of 47 cases, that the third of these states is very rare, that the second condition is the common one, and that the fourth or complete condition is commoner than the first or least state of development, which is also rare. Of Struthers' cases the majority seem to belong to Gruber's second class, while that on the left side in Struthers' Case 4 must have approached Class 1, and that on the left side in Case 10 belonged to Class 3.

Two features in this evidence are of especial consequence: first

[1] Gruber considered that cervical ribs in Man are probably of two kinds, the one arising by development of an "epiphysis" on the superior transverse process, and the other by development of the "rib-rudiment" contained in the inferior transverse process. It is of cases of the latter kind that he is here speaking.

that the variation is more common on both sides than on one side; secondly, that it is not in its lowest development that it is most frequent, but rather in a condition of moderate completeness, having the proper parts of a true rib.

(*b*) From dorsal towards cervical type.

14. Reduction of ribs in the first dorsal is described by Struthers in a specimen in the Path. Mus. of Vienna. "The whole of the cervical vertebræ being present[1] there is no doubt as to the case being one of imperfect first rib. On left side rib goes about $\frac{2}{5}$ round, and articulates with a process of the second rib. On right side it joins second rib at from $\frac{1}{2}$ 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." STRUTHERS, *J. Anat. Phys.*, 1875, p. 47, *Note.* (See also Nos. 24 and 25.)

(2) *Homœosis between dorsal and lumbar vertebræ.*

15. (*a*) From dorsal towards lumbar type. The characters chiefly distinguishing dorsal vertebræ from lumbars are the presence of ribs attached to the former, and of long, flat transverse processes in the latter. Secondly, the articular processes of lumbar vertebræ generally differ from those of most of the dorsal series, each pair of articular surfaces facing inwards and outwards respectively instead of upwards and downwards as they do in the dorsal region. The transition from the one type of process to the other, in passing down the column, is generally an abrupt and not a gradual one. In Man it occurs between the 12th dorsal and 1st lumbar, but in most Mammals it takes place more or less in front of the last dorsal, leaving several dorsal vertebræ with articular processes of the lumbar type. (STRUTHERS, *l. c.*, p. 59.)

Cases of rudimentary 12th rib in Man are not rare. When the last dorsal in this respect approaches to the lumbar type, the change of the articular process from dorsal to lumbar may take place higher than normally, as in STRUTHERS' Cases 1 and 2 (*l. c.* p. 54 and p. 57). In both of these the change was symmetrical, and in the first case it was abrupt and completed between the 11th and 12th dorsals, but in the second it was less complete. Though the place at which the change of articular processes takes place here varies in correlation with the diminution of the last ribs, both being higher than usual, such correlation is not always found, change in respect of either of those characters sometimes occurring alone.

[1] Struthers points out that unless the cervical vertebræ above the rudimentary ribs are counted there can be no certainty that in any given case these ribs are not extra cervical ribs.

(*b*) From lumbar towards dorsal type.

16. The formation of moveable ribs upon vertebræ normally belonging to the lumbar groups is in Man rarer than reduction of the 12th ribs. In these cases the ribs may or may not coexist with transverse processes of considerable size. In a case of 13th rib in Man, given by Struthers (*l. c.*, p. 60), the change of articular processes occurred a space lower than usual, being thus correlated with the appearance of ribs at a lower point.

(3) AND (4). *Homœosis between lumbar, sacral and coccygeal vertebræ.*

17. The differences between the vertebræ of these regions are far more matters of degree than those between the members of other vertebral regions. By detachment of the 1st sacral (25th vertebra) the lumbars may become 6, and in this case the 2nd sacral wholly or partially takes the characters proper to the 1st sacral, but this change is not necessarily accompanied by union between the last sacral and the 1st coccygeal (see, for example, STRUTHERS, *l.c.*, p. 68). On the other hand, the last lumbar may unite with the 1st sacral, and such union may be either symmetrical or unilateral only. The amount to which the ilium articulates with these vertebræ and the degree to which their processes are developed to support it also present many shades of variation. Similarly the last sacral may be free, or the 1st coccygeal may be united to the sacrum.

Since all these changes are manifestly questions of degree it would be interesting to know whether any particular positions in the series of changes are found more frequently than others, but I know no body of statistics from which this might be determined. In the absence of such determination there is no reason to suppose the existence of Discontinuity in these variations.

HOMŒOTIC VARIATION, VERTEBRÆ AND RIBS.

II. *More Complex Cases.*—**Man.**

From examples of the occurrence of Homœosis between members of the several regions we have now to pass to the more interesting question of the degree to which Homœosis in one part of the column may be correlated with similar Homœotic variation in the other parts. For, though each of the particular changes in the various regions may occur without correlated change in other regions, such correlation nevertheless often occurs, and in any consideration of magnitude of Variation it is a factor of importance. In several of the examples to be given it will be seen that the redistribution of regions is also associated with Meristic change in the total number of segments in the column. It is obvious that in

the present place only the most summary notice of the various cases can be given.

Amongst them can be recognized two groups, the first in which the Homœosis is *from before backwards*, the second in which it is *from behind forwards*.

A few words in explanation of the use of these terms are perhaps needed.

In describing cases of such transformation in the series, it is usual to speak of structures, the pelvis for example, as "travelling forwards" or "travelling backwards." These modes of expression are to be avoided as introducing a false and confusing metaphor into the subject, for there is of course no movement of parts in either direction, and the natural process takes place by a development of certain segments in the likeness of structures which in the type occupy a different ordinal position in the series. In using the expression, Homœosis, we may in part avoid this confusion, and we may speak of the variation as occurring from before backwards or from behind forwards, according as the segment to whose form an approach is made stands in the normal series behind or in front of the segment whose variation is being considered. The formation of a cervical rib on the 7th vertebra is thus a backward Homœosis, for the 7th vertebra thus makes an approach to the characters of the 8th. On the other hand development of ribs on the 20th vertebra (1st lumbar), is a forward Homœosis, for the 20th vertebra then forms itself after the pattern of the normal 19th[1].

A. *Backward Homœosis.*

If each segment in the series of vertebræ were to be developed in the likeness of that which in the normal stands in the position next posterior to its own, we should expect the whole series to be one less than the normal. The following case makes an approach to this condition.

*18. Skeleton of old woman. C 7, D 11, L 5, S 5, C 4 (5th and 6th cervicals partially ankylosed). The 7th cervical bore a pair of cervical ribs [of Gruber's class 2, see p. 108], that on the left being ankylosed to the 7th cervical. There were only 11 pairs of thoracic ribs. The 1st lumbar was a true lumbar. GRUBER, WENZEL, *Mém. Ac. Sci. Pét.*, 1869, *Sér.* VII., XIII., No. 2, p. 23. Here the 7th vertebra resembles a dorsal in having ribs, the 19th, which in the type is the last dorsal, resembles a lumbar in all respects, the 24th is the 1st sacral, and there is no 33rd vertebra.

[1] The same terminology may conveniently be adopted in the case of the parts of flowers. Development of petals in the form of sepals being an *outward* Homœosis, while the formation of sepaloid petals would be thus called an *inward* Homœosis, and so forth.

*19. Male, in Cambridge Univ. Mus., No. 78. Preparation shews C 7, D 11, and the 19th vertebra formed as the 1st lumbar: remainder not preserved, but Professor A. Macalister kindly informs me that there were 5 lumbars and 5 sacrals, giving C 7, D 11, L 5, S 5. The 7th vertebra has cervical ribs, the left being large and articulating with a tuberosity on 1st thoracic rib, the right being considerably smaller, but now broken at the end. Only 11 pairs of thoracic ribs. Change of articular process from dorsal to lumbar begins partially on the left side between 17th and 18th vertebra (instead of between 19th and 20th) and is complete on both sides between 18th and 19th. The 19th bears no rib. [Backward Homœosis, greater on left side than on right, as seen in the greater size of the left rib on the 7th vertebra, and in the change of processes beginning at a higher level on this side. As the coccyx is not preserved it cannot be seen whether there is one segment less in the whole column, which would be the case were the backward Homœosis complete.]

20. Female, *æt.* 40. C 7, D 12, L 5, S 6, C 3. The 7th vertebra bore cerv. ribs, free on left, ankylosed to vertebra on right. Change of artic. processes partially on left side between 18th and 19th (instead of between 19th and 20th). Twelfth thoracic ribs short, being $1\frac{1}{8}$ in. long on left, $1\frac{3}{4}$ in. on right. STRUTHERS, J., *J. Anat. Phys.*, 1875, pp. 53 and 35. [There is therefore backward Homœosis, greater on the left side than on the right.]

21. Vertebræ C 7, D 11 or 12, L 5 or 4, S 6, C lost. Eleven pairs of ribs. The 19th vertebra having a transverse process on the left side resembling that of the vertebra next below it, as regards place of origin and its upward slope, but is longer than it by $\frac{1}{8}$ in. and is nearly a third broader and also thicker. On *right* side corresponding part is in two pieces. Change of articular processes complete between 18th and 19th (instead of between 19th and 20th). The 24th vertebra is united to sacrum, but is of unusual shape, differing greatly from a normal 1st sacral (25th vertebra). The 29th vertebra is nevertheless not detached from sacrum. STRUTHERS, *l. c.*, pp. 70 and 57.

22. Adolescent subject. *7th cervical, 12 dorsals and ribs, and 3 lumbars* preserved. 11th ribs reduced, 4 in. long, $4\frac{1}{2}$ in. with cartilage. 12th ribs rudimentary, left 1 in., right $\frac{3}{4}$ in. long, breadth of each about $\frac{1}{8}$ in. Artic. processes change chiefly between 18th and 19th vertebræ. STRUTHERS, *l. c.*, p. 55.

23. Male, *æt.* 47. C 7, D 12, L 5, S 5, C 4. Twelfth ribs very unequal; right scarcely 2 in., left $3\frac{1}{2}$ in. The 5th lumbar ankylosed to sacrum by its right transverse process. STRUTHERS, *l. c.*, p. 57. [Backward Homœosis on right side in respect of reduction of 12th rib and union of 24th vertebra to sacrum on that side.]

B. *Forward Homœosis.*

As was remarked in the case of backward Homœosis, if each vertebra were to be developed in the likeness of the one which in

the normal stands next behind it in ordinal sequence, we should expect such backward Homœosis to be accompanied by *reduction* in the total number of vertebræ; so, conversely we should expect forward Homœosis to be accompanied by an *increase* in total number. This will be found to be sometimes the case (*e.g.* No. 26).

*24. Male. C 7, D 13, L 5, S 5 [C not recorded]. 13 ribs on each side. The right side differed considerably from the left.

Right side. 1st rib resembled the usual supernumerary cervical, being moveable and extending $\frac{3}{4}$ in. from its tubercle. Greater part of IXth nerve crossed the neck of the rib; just before doing so *it was joined by large branch of* Xth. The 2nd rib, borne by ninth vertebra, in all respects resembled a normal 1st rib. The 3rd rib articulated with sternum like a normal 2nd rib. In all, 8 ribs articulated with sternum on right side, as usual. The 13th rib (on 20th vertebra) was $4\frac{1}{2}$ in. long.

Left side. The 1st rib articulated with body and transverse process of 8th vertebra, connecting with sternum in normal position, but differing much from a normal 1st rib, being nearly straight with very slight horizontal curve. 2nd rib normal in form and direction; articulates with sternum $\frac{1}{3}$ in. higher than right 3rd rib, owing to the lower margin of manubrium being directed slightly obliquely upwards and to the left. In all, 8 ribs articulated with sternum, all below the first being at a level slightly higher than that of the right ribs. The 13th rib (on 20th vertebra) was $4\frac{3}{4}$ in. long. LANE, W. ARBUTHNOT, *J. Anat. Phys.*, 1885, p. 267 [full description and discussion].

In this remarkable case, by the reduction of the 1st rib on the right side, the 8th vertebra shews a forward Homœosis so far as that side is concerned. The 20th vertebra, bearing a pair of 13th ribs, also shews a forward Homœosis, but this seems to have been a little greater on the left than on the right (cp. No. 20), the right rib being a $\frac{1}{4}$ in. less in length. The fact that a large branch of the Xth nerve on the right side joined the brachial plexus instead of the usually minute fibre is specially noteworthy, as shewing a forward Homœosis in the brachial plexus on the right side in correlation to the similar Homœosis appearing in the reduction of the 1st rib on the same side. (Compare Nos. 14 and 25.)

25. Skeleton C 7, D 12, L 6 [S and C not recorded]. First pair of ribs rudimentary, about $1\frac{1}{2}$ in. long, exactly alike, as small horns attached to 8th vertebra. Scalene muscles were inserted into 2nd rib. The 25th vertebra was free, but the first lumbar (20th vertebra) had no trace of a rib. BELLAMY, E., *J. Anat. Phys.*, 1885, p. 185.

[In this case there is forward Homœosis in the reduction of the first ribs and in the formation of the 25th vertebra as a lumbar, but there were no ribs on the 1st lumbar, which would

have been expected had there been an even Homœosis throughout the dorso-lumbars.]

*26. Male, *æt.* 50. C 7, D 12, L 6, S 5, C "3 or 4, probably 4." Thirteen pairs of ribs, 13th ribs on 20th vertebra, nearly symmetrical, right 2 in. long; left $1\frac{7}{8}$, and in breadth a little less than the right. The 6th lumbar, 25th vertebra, had the characters of a normal last lumbar (sc. 24th vertebra), including normal transverse processes. Coccyx in 3 moveable pieces, the 3rd apparently composed of two. There is therefore probably one more than the normal number in the whole series. STRUTHERS, *J. Anat. Phys.*, 1875, p. 62.

27. Male, *æt.* 56. C 7, D 12, L 6, S 5, C 3. Dorsal vertebræ and ribs normal. 20th vertebra normal, except that it has no trace of transverse processes; ribs have perhaps been present on it. 25th vertebra quite free from sacrum, but articulating with ilium by small facet on each side. The 1st coccygeal joined to sacrum. STRUTHERS, *l. c.*, p. 66 and p. 91. [Homœosis in absence of trans. processes in 20th vertebra, in separation of 25th from sacrum, and in union of 30th with sacrum.]

28. Skeleton C 7, D 12, L 6, S 5, C lost. The 25th vertebra is separate from the ilium and the sacrum, but the 30th is united to the latter. STRUTHERS, *l. c.*, p. 69.

29. Male, *æt.* 29. C 7, D 12, L 6 (1st bearing ribs—6th partially joined to sacrum), S 5 (exclusive of 5th lumbar), C 4. 20th vertebra bearing ribs; 25th partially free from sacrum but partly supporting the ilium, and one extra vertebra in the series. STRUTHERS, *l. c.*, p. 64 and p. 92.

30. Skeleton D 12, L 6, S 4, C 4. The 25th vertebra by right transverse process articulates with sacrum and on the same side with the ilium; the 30th, however, though moveable on the sacrum, has characters transitional between those of a 5th sacral and a 1st coccygeal. STRUTHERS, *l. c.*, p. 68 and p. 91.

31. Male. C 7, D 13, L 5, S and C ankylosed together of uncertain number. Articular processes change between 20th and 21st, i.e. a space lower than usual, but the processes between 19th and 20th are smaller than those higher up and are not quite symmetrical. The 20th vertebra bore rib on left side and rib has apparently been present on right, but probably not so much developed. STRUTHERS, *l. c.*, p. 64, *note.* [Forward Homœosis in development of ribs on 20th and in detachment of 25th.]

But though the variations of the vertebræ may thus in great measure be reduced to system, there remain other cases, rare in Man but not very uncommon in lower forms, which cannot be brought into any system yet devised. Such cases shew that the limits imposed by a system of individual homologies, between which we conceive the occurrence of Variation, are not natural limits, and that they may be set aside in nature. In the following case it may be especially noted that Variation in the segmentation of the

spinal nerves does not necessarily coincide with that of the vertebræ. This fact will be more fully illustrated in the section of evidence respecting the spinal nerves.

*32. Female, *æt.* 40. As it stands, the grouping is C 6, D 12, L 6, S 5, C 3; in all 32, viz. one less than usual. The vertebral artery did not enter till 5th cervical (instead of 6th) on left side. The 7th vertebra bore a pair of ribs, left small, ceasing at middle of shaft; right has been sawn off, but has all the appearance of a rib that would have reached the sternum. The 19th vertebra bore no ribs, and has transverse processes like those of a normal 1st lumbar. 23rd has transverse processes triangular and sloping upwards, like those of normal last lumbar but one (sc. 23rd), though in a less degree: pedicle thicker than usual for this vertebra.

The articular processes change in the normal space, between 19th and 20th vertebræ. Sacrum 5; Coccyx represented by 3 pieces ankylosed together.

Two entire lumbar nerves went down from the lumbar region to the sacral plexus. [Bones described in detail, *q. v.*] STRUTHERS, *J. Anat. Phys.* 1875, p. 72 and p 29.

Here then the 7th vertebra shews backward Homœosis, imperfect on left side, but more complete on right. 19th having no ribs, shews the same, and this also appears in the absence of a 4th coccygeal. The fact that two entire lumbar nerves join the sacral plexus is also a variation of the same kind. But if the backward Homœosis were complete, the 24th vertebra should be the 1st sacral, and the 29th should be joined to the coccygeal. The change of articular processes moreover is in the normal place.

An example like this brings out the difficulty that besets the attempt to find an individual homology for each segment. If the characters proper to each segment in the type may be thus redistributed piecemeal amongst a different total number of segments, the question, which in this body corresponds to any given vertebra, say the 25th, in a normal body, cannot be answered. The matter is thus clearly summed up by STRUTHERS (*l. c.* p. 75):

"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 vertebræ 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 vertebræ 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."

To the question, which vertebra is missing, there is no answer; or rather the answer is that there is *no* segment in this body strictly corresponding to the normal 7th, 20th, 25th, &c.; that the characters of these several segments are distributed afresh and upon no strict, consistent plan among the segments of this body, and that, therefore, there is no one segment missing from the body. Surely further efforts to answer questions like these can lead to no useful result.

Attempts to interpret Variation by the light of simple arithmetic serve only to obscure the real nature of Repetition and segmental differentiation; for by constantly admitting to the mind the fancy that this simple, subjective representation of these processes is the right guide, and that the tangible complexity in which they present themselves is a wrong one, we only become used to an idea which is not true to the facts and the real difficulty is shirked.

ANTHROPOID APES.

Though adding little that is new in kind to the foregoing specimen-cases occurring in Man, the following instances of Variation in the vertebræ of the Anthropoid Apes are of some interest if only as illustrations of the fact that the frequency of such Variation has no necessary relation to the conditions of civilization or domestication. (On the subject of Variation in the vertebræ of Anthropoids, see especially ROSENBERG's list, *Morph. Jahrb.* I. p. 160.)

Troglodytes niger (the Chimpanzee).

[In considering cases of variation in the Chimpanzee it should be borne in mind that there are several races and perhaps species included under this name, which have not been clearly distinguished. It is possible, therefore, that some of the variations recorded may be characteristic of these races and not actually individual variations.]

C 7, D 13, L 4, S 5.

This is the formula in the great majority of Skeletons (*v. auctt.*).

33. An adult female having C 7, D 12, L 4, S 5, C 5, viz. one vertebra and one pair of ribs less than usual. This is a specimen of DU CHAILLU's *T. calvus*. It was received united by the natural ligaments and no vertebra therefore is lost. *Cat. Coll. Surg.*, 1884, II. No. 4.

34. Specimen having rudimentary ribs unequally developed on the 21st vertebra. The 25th vertebra was transitional or lumbo-sacral in character. The 26th—30th formed the sacrum and there were 6 caudals, while other specimens had from 2 to 4. For the lumbo-sacral plexus of this specimen, see No. 71. ROSENBERG, *Morph.*

Jahrb., I. p. 160. *Tables*, *Note* 19. This case therefore shews forward Homœosis in the presence of ribs on the 21st, also in the transitional character of the 25th, together with increase in total number. This increase is however not always found when the 25th is lumbo-sacral, for, on the contrary one such case quoted by Rosenberg had only 4 caudals (*q.v.*).

In this form the number of vertebræ articulating with the ilium varies, and the number uniting with the sacrum is also liable to alterations probably connected with age. ROSENBERG, *l. c.*; *Cat. Coll. Surg.*, 1884, II. p. 3.

Gorilla savagii. C 7, D 13, occur in all skeletons of which I have found descriptions, making therefore one pair of ribs more than in Man[1].

The number of vertebræ articulating with the ilium and the number joining with the sacrum vary, perhaps with age. Cf. ROSENBERG, *l.c.*; *Cat. Coll. Surg.*; STRUTHERS, *J. Anat. Phys.*, 1875, p. 79 *note*, &c.

*35. Adult female. C 7, D 12, L 4, S 5, C 3. This is a remarkable case. There is one rib-bearing vertebra less than usual, while the number of lumbo-sacrals is nine, as in the normal cases collected by Rosenberg. In a normal skeleton in the Camb. Mus. the articular processes change from the dorsal to the lumbar type between the 20th and 21st, but in this abnormal specimen the change is completed on the right side between the 19th and 20th as in Man, and on the left side, though the change has there also taken place, there is a curious irregularity in the fact that the posterior zygapophysis of the 19th is divided to form two processes which fit into two similar processes of the left anterior zygapophysis of the 20th vertebra. The rest is normal. *Cambridge Univ. Mus.*, 1161, F. [There is here, therefore, a backward Homœosis of all vertebræ from the 19th onwards; perhaps also an absolute diminution in the total number of segments. The simultaneous variation of both the number of ribs and the position of the

[1] Since this account was written, STRUTHERS has published a valuable paper (*Journ. Anat. Phys.*, 1892, XXVII. p. 131), giving particulars of twenty Gorilla skeletons. Of these the following are especially remarkable.

Female, C 8, D 13, L 3. The seventh cervical is formed like a sixth, and the eighth is formed as a seventh, bearing no rib. The vertebræ 9 to 21 bear ribs, those of the 21st being well formed and coming close to iliac crest. The change of articular processes from dorsal to lumbar type occurred between 21st and 22nd, namely, one vertebra lower than usual. There is thus a forward Homœosis in absence of ribs on 8th, in presence of ribs on 21st, and in the variation of position of the articular change.

Out of 20 skeletons 3 have 14 pairs of ribs (on 8th to 21st) instead of 13 pairs. In one of these the articular change also occurred one vertebra lower than usual. On p. 136 a case is described in which there was a remarkable asymmetry in the structure of the articular processes, which as Dr Struthers has pointed out to me, is in some respects like that here described as No. 35 in the text.

Struthers points out that it would be better in all cases to speak of the change of processes as from lumbar to dorsal instead of from dorsal to lumbar. I regret that this suggestion comes too late for me to adopt.

change of articular processes to the human numbers is especially worthy of notice.]

* **Simia satyrus** (Orang-utan). Out of eight skeletons in the Mus. Coll. Surg., C 7, D 12, L 4 occurs in seven. In young specimens the distinction between the last lumbar and the first sacral is clearly shewn by presence of pleurapophysial ossifications in the transverse processes of the latter. Thus though *Simia* resembles Man in the number of ribs, it differs in the total number of praesacral vertebræ. *Cat. Mus. Coll. Surg.*, 1884, II. p. 10.

The arrangement C 7, D 12, L 4, S 5 occurs in a great number of specimens (for cases quoted, see ROSENBERG, *Morph. Jahrb.*, I. p. 160, Tabellen; *Cat. Mus. Coll. Surg.* &c.)

36. Adult male, Sumatra. C 7, D 11, L 5, S 5, C 2. *Mus. Coll. Surg.*, No. 37.

37. Fœtal skeleton. C 7, D 11, L 5, S 5, C 2. TRINCHESE, S., *Ann. Mus. civ. Storia nat. Genova*, 1870, p. 4.

38. Adult. C 7, D 11, L 4, S + C, ankylosed together, containing 8 ? pieces. *Camb. Univ. Mus.*, 1160, A.

39. Adult. C 7, D 12, L 4, S 4, C 3. The last lumbar shared in supporting iliac bones. DE BLAINVILLE, *Ostéogr.*, Primates, *Fsc.* I. p. 29.

40. A young specimen, well preserved: there were certainly L 4, S 3, C 4, but in the adult mentioned above, one of the coccygeal was joined to the sacrum. DE BLAINVILLE, *ibid.*

41. Young specimen in spirit, C 7, D 12, L 4, S 5, C 2. ROSENBERG, E., *Morph. Jahrb.* I. p. 160.

42. Specimen in spirit, not full grown, C 7, D 12, L 4, S 5, C 1. There was no doubt that only one coccygeal was present. ROSENBERG, *ibid.*

43. [**Hylobates.** Considerable differences in the number of vertebræ and ribs found in this genus are recorded in the Catalogue of the Museum of the College of Surgeons, &c.; since however the specific divisions of the genus are very doubtful (see *Catalogue*, II. p. 15), it is not possible to consider these as necessarily individual variations. See also ROSENBERG, *l.c.*, *Tables.*]

BRADYPODIDÆ.

To the study of Variation of the vertebral regions the phenomena seen in the Sloths are of exceptional importance, and in attempts to trace the homologies of the segments special attention has always been paid to them. The following table contains brief particulars of 11 specimens of *Bradypus* and 11 of *Cholœpus* seen by myself in English museums, and of a few others of which descriptions have been published. To these is added a summary of 40 specimens of *Bradypus* and 9 of *Cholœpus* in German museums[1] examined by WELCKER. His account is unfortunately not given in detail, but I have tabulated his results so far as is

[1] viz. Göttingen, Tübingen, Marburg, Leipzig, Frankfurt, Berlin, Giessen, Jena and Halle.

possible. Welcker's list does not, I believe, include any of the specimens separately given in No. 44.

The determination of the *species* is quite uncertain. Welcker in his analysis does not divide the species of *Bradypus*. In the other cases I have simply taken the name given on the labels. As regards *Cholœpus* the confusion of species is much to be regretted, for according to the received account[1] the more northern species, *C. hoffmanni*, has only 6 cervicals, while *C. didactylus* has 7. In the table it will be seen that four specimens in different places have C 6, though generally marked *C. didactylus*. Possibly some or all of these are *C. hoffmanni*, and I have therefore entered them as *Cholœpus* sp. In the case of *Bradypus* it has not been alleged that the number of cervicals characterizes particular species, so the fact that the species are confused is of less consequence.

*44. Bradypus.

	C	*D*	*L*	*S*	*C*	
B. tridactylus	9	15	4	6	5+	C^8 minute c. r. rt. C^9 large c. r. both sides (one lost). D^{15} moveable r. rt., fixed on l. *Camb. Mus.*
,,	9	15	4	6	8+	C^9 no rib. *Coll. Surg.* 3427.
,,	9	15	4	6	9?	*Brit. Mus.* 919 *a*.
,,	9	15	4	5	12	*Brit. Mus.* 52. 9. 20. 5.
,,	9	15	4[5]	5	10	C^9 c. r. ½ in. long. *Univ. Coll. Lond.*
,,	9	14	4	5	11	C^9 c. r. {l. ¾ in. rt. ½ in. *Coll. Surg.* 3428.
sp.?	9	14	4	5	9	*Oxford Mus.*
,,	9	16	3	6	11	*Coll. Surg.* 3422.
,,	8	15	3	7	9?	7th sacral only ankylosed in part. *Brit. Mus.* 46. 10. 16. 14.
,,	9	15	4	5	11	C^9 small rib-like horn on l. *Mus. Med.-Chir. Acad. Pétersb.* GRUBER[2].
sp.?	9					GRUBER'S *private collection*[2].
,,	9	STRUTHERS[3]				C^8 may have borne rib on rt. C^9 { l. free c. r. 1st thoracic complete. rt. c. r. ankylosed. 1st thor. ½ in. long, like a c. r.; ankylosed.
B. cuculliger	9	15	4	6	9	C^9 has pair short c. r. *Brit. Mus.* 921 *b*.
B. torquatus	9	14	4			GRUBER[2].
ditto			5	6	10	*Brit. Mus.* 47. 4. 6. 5.
Bradypus sp.	8	15				3 specimens from Brazil said to have 8 cervicals. No detailed account given. DE BLAINVILLE[4].
,, sp.	8	15				
,, sp.	8					

[1] FLOWER, W. H., *Mammals, Living and Extinct*, 1891, p. 183.

[2] GRUBER, *Mém. Imp. Ac. Sci. Pét.* Ser. VII., XIII. 1869, no. 2, p. 31.

[3] STRUTHERS, *Jour. Anat. Phys.*, 1875, p. 48 note.

[4] DE BLAINVILLE, *Ostéogr.*, Fsc. v., pp. 27, 28 and 64. In the place cited, de Blainville gives *C* 9, *D* 16, *L* 3, *S* 6, *C* 9—11 as the normal, but he does not say in how many specimens this formula was seen. I have therefore been unable to tabulate this observation. It will be seen that *D* 16 is quite exceptional, but as it occurred in the Coll. Surg. specimen no. 3422 it was described by OWEN as the normal, and this statement has been copied by many authors, perhaps by de Blainville.

[5] Fourth lumbar ankylosed to sacrum by tr. proc.

SUMMARY OF 40 CASES: WELCKER[1].

Bradypus	*C*	*D*	*L*		
	10	14	4	C^{10} no c. r. 2 cases[2].	
	10	14 or 15	4 or 3	C^{10} with c. r. of fair size. 3 cases.	On C^9 c. r. very small or absent. 29th is 1st sacral.
	9	15 or 16	4 or 3	9 cases.	
	9	15	3	15 cases.	C^9 usually with *c. r.* *21 cases.* 28th is 1st sacral.
	9	14	4	*6 cases.*	
	9 or 8	14 or 15	3	C^9 has either large c. r. or complete r. 5 cases. (This normal in *B. torquatus*: once in *B. cuculliger*.)	27th is 1st sacral.

(c. r., cervical rib. C^6, C^7, &c., sixth, seventh cervical vertebra, &c.)

*45. Cholœpus.

	C	*D*	*L*	*S*	*Cd*	
C. didactylus	7	23	3	8	4	*Coll. Surg.* 3435.
,,	7	24	3	7		*Oxford.*
,,	7	23	4	5		*Coll. Surg.* 3427 (*Catalogue*).
,,	7	23	3	7	6	*Coll. Surg.* 3424.
sp.	6	24	3	6	5	*Cambridge.*
sp.	6	23	3	9	3 or 4	*Brit. Mus.* 65. 3. 4. 5.
sp.	6	22	4	8	5	*Univ. Coll. Lond.*
sp.	6	21	3	8	5?	*Brit. Mus.* 1510 *b*.
C. hoffmanni	6	22	5	8	5?	*Brit. Mus.* 1510 *c*.
,,	6	21	4	7	5	*Coll. Surg.* 3439.
C. hoffmanni?	6[3]	23	2	7	4?	*Brit. Mus.* 80. 5. 6. 84.

SUMMARY OF 9 CASES: WELCKER[4].

	C	*D*+*L*	
C. didactylus	7	27	1st sacral is the 35th. 2 cases.
,,	7	26	1st sacral is the 34th. 2 cases.
C. hoffmanni	6	27	1st sacral is the 34th. 1 case.
,,	6	26	1st sacral is the 33rd. 1 case.
,,	6[5]	25	1st sacral is the 32nd. 3 cases.

[1] WELCKER, *Zool. Anz.* 1878, I. p. 294.

[2] This includes the celebrated specimen (in natural ligaments) described by RAPP, *Anat. Unters. d. Edent.*, Tübingen, ed. 1843, p. 18.

[3] This specimen is labelled *C. didactylus*, but coming from Ecuador and having this formula is probably *C. hoffmanni*. (Compare THOMAS, O., *P. Z. S.*, 1880, p. 492.) In it C^6 bears cervical rib articulating with shaft of the first thoracic rib.

[4] *Zool. Anz.* 1878, I. p. 295.

[5] In a specimen in Leipzig Museum, no. 459, the 6th cervical bears large ribs, of which the right nearly reaches the sternum, so that Welcker says that there are only 5 true cervical vertebræ. In another of these specimens there is a cervical rib on C^6 measuring 19 mm.

On this evidence several comments suggest themselves. First it should be noted that the Bradypodidæ strikingly exemplify the principle which Darwin has expressed, that forms which have an exceptional structure often shew an exceptional frequency of Variation. Among Mammals the Sloths are peculiar in having a number of cervicals other than 7, and from the tables given it will be seen that both the range and the frequency of numerical Variation is in them very great, not only as regards the cervicals, but as regards the vertebræ generally.

As concerning the correlation between Variation in the several regions, WELCKER points out that his results go to shew that there is such a relation, and that when the sacrum is far back, the ribs also begin further back, or at least are less developed on the cervicals. As he puts it. with a long trunk there is a long neck. This is a very remarkable conclusion, and it must be admitted that it is, to some extent, borne out by the additional cases given above. The connexion, however, is very irregular. For instance, the Cambridge specimen of *Bradypus*, though the 29th is the 1st sacral, has had cervical ribs of good size on the 9th vertebra, and even has a small one on the 8th. But taking the whole list together, Welcker's generalization agrees with the great majority of cases. Expressed in the terms defined above, we may therefore say that backward Homœosis of the lumbar segments is generally, though not quite always, correlated with backward Homœosis of the cervicals, and *vice versa*.

It will be seen further that this Variation concerns every region of the spine, and that even in the total number of præ-sacral vertebræ there is a wide range of variation, viz. from 27 to 29 in *Bradypus* (52 specimens) and from 30 to 34 in *Cholœpus* (20 specimens). Perhaps no domestic mammal shews a frequency of variation in the fundamental number of segments comparable with this. In this connexion it may be observed that the absolute number of dorso-lumbars in *Cholœpus* (25—27) is exceptionally large amongst mammals; but this is not the case in *Bradypus*.

If the case of *Bradypus* stood alone, some would of course recognize the occurrence of cervical ribs on the 9th and 8th vertebræ as an example of atavism, or return to the normal mammalian form with 7 cervicals. The occurrence of normal ribs on the 7th in *Cholœpus* and the occasional presence of cervical ribs on the 6th vertebra in this form, even reaching nearly to the sternum as in Welcker's Leipzig case, obviate the discussion of this hypothesis.

We have, then, in the Bradypodidæ an example of mammals in which the vertebræ undergo great Variation as regards both their total number and their regional distribution. As the tables shew this is no trifling thing, concerning merely the number of the caudal vertebræ, the detachment of epiphyses which may then be

called ribs, or some other equivocal character, but on the contrary it effects besides changes in the number of præ-sacral segments, that is to say, of large portions of the body, each with their proper supply of nerves, vessels and the like, producing material change in the mechanics and economy of the whole body: this moreover in wild animals, struggling for their own lives, depending for their existence on the perfection and fitness of their bodily organization.

CARNIVORA.

The following cases, though few, have an interest as exemplifying vertebral Variation in another Order.

*46. **Felis domestica.** In all the skeletons of FELIDÆ that I have examined the formula is C 7, D 13, L 7, S 3. A specimen of the domestic Cat having C 7, D 14, L 7 is described by Struthers. The change of articular processes from dorsal to lumbar was completed between the 18th and 19th vertebræ but the posterior zygapophyses of the 17th, though of the dorsal type, have to some extent the characters of a transition-joint. As is stated below, the change in the domestic Cat normally occurs between the 17th and 18th. In this case therefore with increase in numbers of ribs the position of the articular change has varied. This case is described by STRUTHERS, *J. Anat. Phys.*, 1875, p. 64, *Note*, but the description there given differs in some respects from that stated above, which is taken from a letter kindly written by Professor Struthers in answer to my inquiries.

There is here forward Homœosis in the development of ribs on the 21st vertebra, in the alteration in position of the articular change, and in the fact that the 28th is not united to the sacrum.

As seen in some other cases, therefore, with forward Homœosis the number of præ-sacral vertebræ is increased; but as usual owing to the equivocal nature of caudal vertebræ it is not possible to state that the total number of vertebræ is greater.

Canis vulpes. Normally, C 7, D 13, L 7; articular change from dorsal to lumbar between 17th and 18th.

47. Specimen having C 7, D 14, L 6, in which further the articular change occurs partly between the 17th and 18th, and partly between the 18th and 19th. In *Mus. Coll. Surg. Edin.* Information as to this specimen was kindly sent me by Professor STRUTHERS.

48. **Jackal.** Specimen having C 7, D 13, L 8 instead of 7. Articular change as usual between 17th and 18th. STRUTHERS *in litt.*

49. **Canis familiaris.** Case of cervical rib on left side borne by 7th cervical. This rib was $1\frac{1}{2}$ in. long and articulated with a tubercular elevation on the 1st thoracic rib of the same side. The remaining ribs and vertebræ were normal. [fully described] GRUBER, W., *Arch. f. Anat. Phys., u. wiss. Med.*, 1867, p. 42, Plate.

[In connexion with the foregoing observations it may be mentioned that the articular change does not take place in the same place in all Felidæ. In 4 specimens of *F. leo*, 2 of *F. tigris* and 2 of *F. pardus*, in Edinburgh, and in one Lion and one Tiger in Cambridge the lumbar type begins between the 18th and 19th as in Struther's abnormal Cat

above described; but in 4 *F. domestica*, and 2 *F. catus* in Edinburgh, 1 *F. domestica*, 1 *F. catus*, 1 *F. concolor* and 1 *Cynælurus jubatus* in Cambridge the change is between the 17th and 18th. For information as to the Edinburgh specimens, I am indebted to Professor STRUTHERS.]

50. **Galictis vittata.** Specimen from Paraná had 16 pairs of ribs, 11 true and 5 false; 5 lumbar, 2 sacral and 21 caudal vertebræ.

A specimen from Brazil had only 15 pairs of ribs and the same number of lumbar and sacral vertebræ. BURMEISTER, *Reise durch d. La Plata-Staaten*, Halle, 1861, II. p. 409.

[This is therefore another case of forward Homœosis, (as manifested in the presence of an additional pair of ribs) associated with an *increase* in the number of præsacral vertebræ.]

51. **Halichœrus grypus.** Phocidæ generally have C 7, D 15, L 5. Specimen of *H. grypus* having C 7, D 15, L 6 at Berlin. The anterior of the six lumbars bears a rudimentary rib about 5 cm. in length on the left side. The 28th vertebra is here detached from the sacrum giving S 3, but generally it is united to it, giving S 4. NEHRING, A., *Sitzb. naturf. Fr. Berlin*, 1883, pp. 121 and 122. There is here therefore a forward Homœosis in the development of a rib on the 23rd, and also in the detachment of the 28th from the sacrum.

REPTILIA.

52. Mr Boulenger kindly informs me that though the number of ventral shields (which is the same as that of the vertebræ) is as a rule very variable in the several species of Snakes as a whole, there is nevertheless great difference in the degree of variability. A case of maximum variation is that of **Polyodontophis subpunctatus,** in which the number of ventral shields has been observed to vary from 151 to 240 (BOULENGER, *Fauna of Brit. India; Reptilia* &c. 1890, p. 303).

53. On the other hand the range of variation in **Tropidonotus natrix** is unusually small. Among 141 specimens examined the number of ventral shields varied from 162 to 190 (STRAUCH, *Mém. Ac. Sci. Pét.*, 1873, XXI., No. 4, pp. 142 and 144).

*54. **Gavialis gangeticus.** In this animal there are normally present 24 præsacral vertebræ and 2 sacrals, the first caudal being the 27th. This vertebra has a peculiar form, being biconvex. Specimen described having 25 præsacrals, 2 sacrals, the 28th being the first caudal. BAUR, G., *J. of Morph.*, IV., 1891, p. 334. In this case Baur argues that since the first caudal is clearly recognizable by its peculiar shape, this vertebra must be "homologous" in the two specimens and he considers that a vertebra must have been "intercalated" at some point anterior to the first caudal by a process similar to that seen in *Python* (see No. 7). In his judgment this has occurred between the 9th and 10th vertebræ, but no reason for this view is given. On the system here adopted, this would be spoken of as a case of forward Homœosis.

55. **Heloderma.** The first caudal in the normal form may be distinguished by having a perforation in the small rib connected with

it. In this it is peculiar. Four specimens shewed the following arrangements:—

H. horridum	No. 1.	First caudal is the 36th vertebra (Troschel).
ditto	No. 2.	.....37th..... .....(Baur).
H. suspectum	No. 1.	.....38th.....(Shufeldt).
ditto	No. 2.	.....39th.....(Baur).

BAUR, G., *J. of Morph.* IV. 1891, p. 335.

BATRACHIA.[1]

*56. **Rana temporaria.** In the normal frog there are nine separate vertebræ in addition to the urostyle. A specimen is described by BOURNE having 10 free vertebræ (Fig. 11, III.). The axis and third vertebra bore tubercles upon the transverse processes, perhaps representing a partial bifurcation of the kind described in No. 58. The ninth vertebra was abnormal in having zygapophyses, and in that its centrum presented two concavities

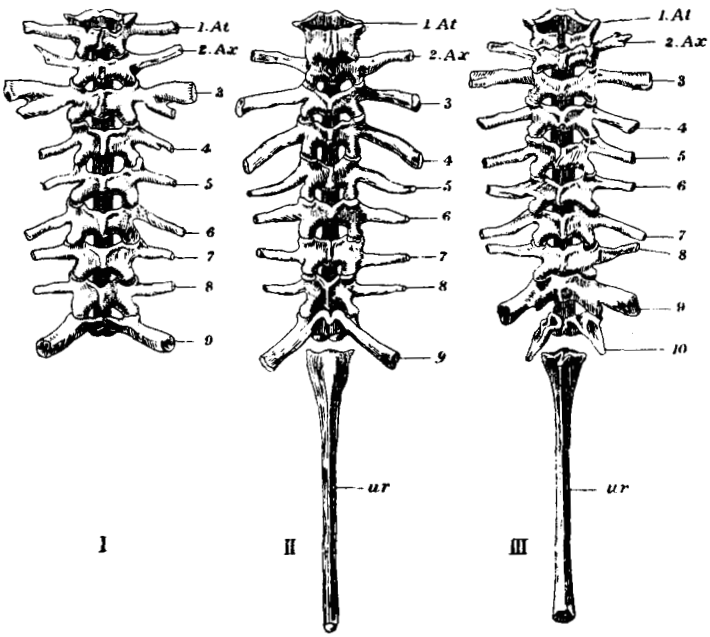

FIGURE 11. Vertebral columns of Frog (*Rana temporaria*), after BOURNE.

I. Specimen having transverse processes borne by the atlas, together with other abnormalities described in text No. 58.

II. Normal Vertebral Column.

III. Specimen having ten free vertebræ, described in text, No. 56.

[1] I regret that the paper bearing on this subject lately published by ADOLPHI, *Morph. Jahrb.*, 1892, XIX. p. 313, appeared too late to permit me to incorporate the valuable facts it contains.

for articulation with a tenth vertebra. The right zygapophysis was well formed and articulated with the tenth, but the left was rudimentary. The tenth vertebra itself had an imperfect centrum and the neural arch though complete was markedly asymmetrical. Posteriorly its centrum presented two convexities for articulation with the urostyle. [For details see original figures.] BOURNE, A. G., *Quart. J. Micr. Sci.*, XXIV. 1884, p. 87.

This is a case of some importance as exhibiting Meristic Variation in a simple form. Of course, as Bourne says, we may say that in this specimen the end of the urostyle has been segmented off and that it is composed of "potential" vertebræ, and as he also remarks, it is interesting in this connexion to notice that some Anura, *e.g. Discoglossus*, present one or two pairs of transverse processes placed one behind the other at the proximal end of the urostyle. But this description is still some way from expressing all that has happened in this case; for beyond the separation of a tenth segment from the general mass of the urostyle there is Substantive Variation in the ninth vertebra in correlation with this Meristic Variation. For the ninth has developed a zygapophysis and has two *concavities* behind, like the vertebræ which in the normal frog are anterior to the ninth. There is therefore a forward Homœosis, associated with an increase in number of segments, just as there is in such a case as that of Man (No. 26) or in that of *Galictis vittata* (No. 50).

It is also interesting in this case to see that the actually last free vertebra here, though it is the 10th, has two *convex* articular surfaces behind like the 9th, which is the last in the normal frog, thus shewing a similar forward Homœosis. Now applying the ordinary conception of Homology to this case, we may, as Bourne says, prove that the 9th in it is homologous with the 9th in a normal frog for its transverse processes are enlarged in the characteristic manner to carry the pelvic girdle. But similarly we may prove also that the *tenth* in this case is homologous with the ninth of the normal, for its centrum has the peculiar convexities characterizing the last free vertebra. Baur's proof that the first caudal was homologous in the two specimens of *Gavialis* (see No. 54) rested on the same class of evidence, and for the moment is satisfying, but as here seen this method though so long established leads to a dead-lock. Upon this case it may be well to lay some stress, for the issues raised are here so easily seen. Besides this the imperfect condition of the extra vertebra enables us to see the phenomenon of increase in a transitional state, a condition rarely found. In the instances recorded in *Gavialis* (No. 54), owing to the perfection and completeness of the variation, the characters of the 1st caudal are definitely present in the 28th though normally proper to the 27th, and therefore it may be argued that the 28th here *is* the 27th of the type. The frog here described shews that in this conclusion other possibilities are not met. On the analogy

of several cases already given, it is not impossible that if the variation seen in this frog had gone further, the 10th vertebra might alone support the ilium (cp. Nos. 57 and 60) and thus present the characters of the normal 9th in their completeness. If this change had taken place, we should have a case like that of *Gavialis*, and there would be nothing to shew that the new 10th vertebra was not the 9th of the normal. The truth then seems to be that owing to the correlation between Meristic Variation producing change in number, and simultaneous Substantive Variation producing a change of form or rather a redistribution of characters, the attempt to trace individual homologies must necessarily fail; for while such determination must be based either on ordinal position or on structural differentiation, neither of these criterions are really sound. As I have tried to shew, the belief that they are so depends rather on preconception than on the facts of Variation.

*57. A male specimen of *R. temporaria* ♂ with *ten* free vertebræ is described by HOWES. In this case the 9th had a posterior zygapophysis on the left side only. Upon the left side the transverse process of the 9th was not larger than that of the 8th and did not support the ilium, which on the left side was entirely borne by the large transverse process of the 10th. On the right side the transverse processes of both 9th and 10th were developed to support the ilium, neither being in itself so large as that of the 10th on the left side. The 9th was concave in front instead of convex as usual, and thus the 8th which is normally biconcave is convex behind. The posterior faces of both 9th and 10th bore two convexities such as are normal to the 9th. The urostyle was normal, having well-developed apertures for exit of the last pair of spinal nerves. HOWES, G. B., *Anat. Anz.*, I. 1886, p. 277, *figures.*

In this case the departure from the normal, exemplified by No. 56, has gone still further, and the new 10th vertebra bears the ilium wholly on the left side and in part on the right. The condition is thus again intermediate between the normal and a complete transformation of the 9th into a trunk vertebra and the introduction of a 10th to bear the ilium (as in No. 60). As regards the homologies of the vertebræ, the same issues are again raised which were indicated in regard to No. 56.

58. **Rana temporaria**: Case in which transverse processes were present in the atlas vertebra and the transverse processes of several of the vertebræ were abnormal (Fig. 11, I.). The atlas possessed well-developed transverse processes.

In the axis the transverse processes are directed forwards instead of backwards, and that of the *left* side presents an indication of bifurcation at its extremity.

The third vertebra possessed two pairs of transverse processes which are joined together for two-thirds of their length. The fourth

vertebra presents a transverse process on the right side which is bifurcated at its extremity.

The remaining vertebræ, though slightly asymmetrical, present no special peculiarity, except that the neural arch of the ninth vertebra is feebly developed. BOURNE, A. G., *Quart. Journ. Micr. Sci.*, 1884, XXIV., p. 86, *Plate*.

There is here backward Homœosis of the atlas, the only case of the kind I have met with[1]. The reduplication of the transverse processes of the third vertebra should be studied in connexion with the cases of double vertebræ in *Python* (No. 7) and the cases of bifid rib (in Man, No. 12), for they present a variation perhaps intermediate between these two phenomena.

Bombinator igneus. In this form there is a considerable range of variation in the development of the transverse processes for the attachment of the pelvic girdle.

59. GÖTTE figures a specimen in which the flat expanded transverse processes have a similar extent on the two sides, but while that on the right side is made up of the processes of the 9th and 10th vertebræ (in about the proportions of two to one), that on the left side is entirely formed by the transverse process of the 10th vertebra. GÖTTE, *Entw. d. Unke, Atlas*, Pl. XIX., fig. 346.

*60. Sardinian specimen figured in which the processes for the attachment of the pelvic girdle seem to be composed entirely by those of the 10th vertebra while those of the 9th are not developed. GENÉ, J., *Mem. Reale Ac. di Torino*, S. 2, I., Pl. V., fig. 4.

61. Specimen figured in which both transverse processes of 9th and of the 10th are almost equally developed to carry the pelvic girdle. CAMERANO, L., *Atti R. Ac. Sci. Torino*, 1880, XV., *fig.* 3.

62. Specimen in which the *left* transverse process of the 9th bears the pelvic girdle on the left side, and the *right* transverse process of the 10th bears it on the right side, while the corresponding processes of the opposite sides were not developed. Similar case recorded in **Alytes obstetricans** by LATASTE, *Rev. int. des Sci.*, III., p. 49, 1879 [not seen, W.B.]; *ibid. fig.* 4.

63. Specimen in which the transverse processes of the 9th alone were developed to carry pelvic girdle, but the proximal end of the urostyle was laterally expanded more than usual, *ibid.* p. 7, *fig.* 3.

[Case of hypertrophy of coccyx, *ibid. fig. 6*; *ad hoc v.* BEDRIAGA, *Zool. Anz.*, 1879, II., p. 664; CAMERANO, *Atti R. Ac. Sci. Torino*, XV., p. 8.]

Recapitulation of important features of Variation as seen in the vertebral column.

I. *As regards fact.*

1. The magnitude of the variations.
2. The rarity of imperfect vertebræ.
3. The phenomenon of imperfect Division of vertebræ and ribs.

[1] ADOLPHI, *l. c.*, p. 352, Pl. XII. fig. 3 gives an account of a specimen of **Bufo variabilis** in which the atlas bore a transverse process on the left side only. In this specimen the first two vertebræ were united and their total length was reduced.

4. The frequency of substantial if imperfect bilateral symmetry in the variations, but the occasional occurrence of asymmetry also.
5. The special variability of some types, e.g. *Simia satyrus*; the Bradypodidæ; *Bombinator igneus*.
6. The evidence that this variability may occur without the influence of civilization or domestication.

II. *As regards principle.*

1. The occasional, though not universal, association of forward Homœosis with increase in number and of backward Homœosis with reduction in number.
2. The frequent correlation between Variation in several regions, such correlated Variation being sometimes unilateral.
3. The impossibility of applying a scheme of Homology between individual segments.