Thesis on the
Spinal Column
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The Spinal Column
and its use in Man and the Lower Animals.

Necessity condensed as an essay like the present
must be, even upon a subject so important, and pertaining
to many features of interest, it shall be my endeavour to
restrict myself avoiding as far as possible any unnecessary en-
largement upon unnatural matters, and adhering only to
the points as stand prominently in the ranks of facts or theories connected with the subject. Thus endeavouring
to keep clear at once of the Sophs of impenetrable con-
ciseness and of the Charabancs of certainty, I propose to
state of the matter as follows:

1. To take a cursory glance at the progress of the deve-
lopment of the spinal column in the different groups
of Vertebrata.

2. To consider its progressive development in its em-
byronic and fetal stages, and its subsequent gradual
ossification.

3. To make a few remarks on "the typical vertebra" of Man,
and the general homologies of the Vertebral column.
14. To notice the adaptation of the constituent parts of the human spine to their different uses, and their modifications in the lower animals for special purposes.

The most essential and persistent portion of the skeleton is that called the Spine or Vertebral Column, which in the majority of the animals possessing it consists of a number of segments (vertebrae) so united as to allow of a greater or less degree of flexibility in different animals, as also in different parts of the spine of the same animal, and giving rise to various appendages, which serve to support and protect important organs, or to assist in the movements of the animal. It is not the province of the present paper, nor indeed is it necessary, to repeat anatomical points which have been so often described, still a short sketch of the principal features of one of these vertebral segments may not be entirely out of place.

Each vertebra then consists of a centre or body, a short, more or less cylindrical spine; from the upper surface of which springs a heavy arch which with similar structures
in the upper vertebra constitutes a bony case for the
passage and protection of the nervous system. Hence the
arches formed by the superior appendages of the vertebra
centra are termed the neural arches (or vertebrae, a bone).
The laminae which by their convergence form these arches
give origin at their summit to the spinae processes, from
each side spring off a transverse process, and from these
processes (articulating), two superior and two inferior con-
nect the vertebra with its fellow above and below.

In this introductory description may be added that
each set of vertebra is named according to its position,
central in the neck, lumbar in the spine, and that at
its posterior extremity the column is usually produced into
a series of vertebra which bends diminishing in size, gra-
dually lose the conspicuous characteristics of each individ-
ual vertebra. Then we have the typical vertebra
of the human anatomist, but the philosophical anatomist
in his "vertebral segment" includes a second arch beneath
the body of the vertebra, which, from its function of protect-
ing organs of the circulatory system, is termed the renal.
(Gr. Hipp. Flood): Of the relations of this second arch, the degree of development of which is very variable, it is not my intention in the present paper to speak to any great extent, but admitting, as in the present state of scientific investigation we must needs do, that any remarks on a subject connected with the vertebral system would be incomplete without mention thereof, I propose to resort in some degree strictly when noticing the Spine in its highest form, in man.

We now proceed in accordance with our proposed division of the subject,

1. To notice the phases of spinal development in the Vertebrata.

In the lower species of the division, the Spine, which by its existence in a higher or lower state of development in all the members gives its name to the group, and of which all the other parts of the structure are said to be regarded as appendages, seems nearly a semi-cordal spine, and (chorda dorsalis) greatly resembling the earliest form of the column in the embryo of the higher Vertebrata; this is seen in the case of the last member of the first
order (Septibranchia) of the first vertebrate class (Pisces).

The Amphineuris Lanceolatus in which creature the spinal column is represented by a gelatinous and supporting the axis of the second system which was imperfectly developed in the column itself, the brain being present; indeed, so indefinite are the appearances of a vertebrate character in that animal that its very title to a place in the division has been disputed by some authors, their considering it a transition form between the Annelidea and the Fishes. For them we probably have the first indication of that column, to draw an outline of its first appearance in the animal system, but destined by progressive development in the higher forms of Vertebrata to form a complicated pillar of support for the entire fabric as well as to protect the delicate nervous centre, which in ceases concurrently thenceforth and at length in man, the apex of the Geological spermadum, to attain a maximum of development, and to form the basis of that structure which by its admirable contour bears him physiologically as far above the rest of the animal creation, as the system
which the same column enclosed by the coverings of a
differing intelligence elevates him above the classes that
pick.
The Spinal Column makes a little step in advance
in the next order of Fishes, the Cyclostomata, the chorda
dorsalis acquiring a somewhat firmer consistence; as we
proceed, we find in the succeeding orders of the class
a partial or entire long column, in some cases however,
the latter retaining almost its original consistency of a simple
chorda dorsalis, when the surrounding parts have reached
the state of cartilage. This is the case in some members
of Order in which, as in the Ganoidea, there is a consid-
erable diversity in the extent of ossification of the column;
in other fishes of the same order the vertebral column and
shall being composed of distinct bones, and in the
Leiostomous, whose development in this respect seems to
approach that of the higher Vertebrata, the anterior sur-
face of the body of each vertebra presents a convex process
fitting into a cavity on the posterior surface of the one
preceeding it. In the rays the cervical vertebrae are
limited so as to form a continuous cylinder: if the
was derived by this and similar unions of vertebrae in the spinal column of various animals, and of other peculiarities in the spines of fishes, I shall say more beneath.

I have hitherto reserved a remark with regard to the persistence of the Chorda dorsalis, or noto-end as it is sometimes called, during the life of the animal, which is interesting in a palaeontological point of view. Some fishes retain this structure as such during their whole lives, and it is presumed to have been the case in the earliest decapods and other fossil fishes of the Devonian era, as well as in those of the Palaeozoic rocks, no remains of a spinal column having been discovered.

We now proceed to the examination of the next class of Batrachia, the Amphibia; and here we shall still find but little advance in development of the spinal column, at least as a whole; noticeable differences however being detected. Here in the lower forms we find it composed of a continuous chorda dorsalis inclosed in a fleshy sheath, but with long superior and inferior arches for the protection of the cord and principal blood vessels. In the higher
found it is a repetition of the vertebral column of the lower fishes, composed of separate vertebrae furnished with long transverse processes, in which latter particular and in the mode of articulation conjoined with the non-existence of the costal appendages in the Amphibia exist the principal differences between the spinal column of that family and the fishes, the consisting partial development of the skull in the Amphibia likewise attracting our attention.

But it is in the next class which presents itself that we Notice the first considerable advance in spinal development; here indeed for the first time we have complete ossification, and a complete union as to the tubs when compared with the last class; for here we find these appendages to the spine developed to an extraordinary extent; in the lizards the humeral arch being completed by a sternum; the mode of articulation of the vertebrae being also of a much higher cast, the degree of mobility permitted by modifications in the last particular is however very variable, having its
extremes in the Snakes and Tortoises.

The next class, namely that of Birds, furnished in place of this further progression. The column exhibits the same division into separate regions as in the other Vertebrata, the characteristic being solidity in all parts except the cervical portion, thus adapting itself to the essence of the faculty of flight. The number of vertebrae in the different regions of the spine is variable, and in this class we find the best specimen of the union of vertebrae which we first notice among the group Reptilia in the class Pterosauria.

Finally in the class Reptilia we find the column reaching its highest development, and divisible into five regions, cervical, dorsal, lumbar, sacral, and caudal; the only exception being in the group Echidna where the sacrum is lost, and a few instances of absence of any caudal vertebrae in some bats. The cervical are constant in number, being seen in the long neck of the Giraffe as in the short neck of the Elephant, to this rule however there is an exception in the case of...
The vertebrae, which possess eight or nine, but here correctly speaking the additional vertebrae are dorsal. The dorsal vertebrae are variable in number, some species possessing only eleven, while others have as many as twenty, but in the number of the lumbar constant. The dorsal portion is usually composed of 9 or 14 vertebrae; the caudal vary in number according to the length of the tail, which in some instances contains as few as 4, in others as many as 50. We have thus very briefly traced the spinal column from its lowest to its highest place in vertebrate animals, and we now proceed to consider its development in its embryonic and fetal stages, and its subsequent gradual ossification. The vertebral column and the cord which it protects, are the first parts formed in the embryo of vertebrate animals; the cord is formed in the primitive groove, i.e. the groove which runs along the median line of the primitive face, and surrounding it, when first developed, is the structure which most immediately
concerns us, the rudimentary spinal column in the form of a tubular structure, destined to a temporary existence in the higher Vertebrata, but permanent in the lower Fishes. This structure, the chorda dorsali, is found to be composed of a narrow linear mass of nucleated cells. From the cells external to this the vertebral column is developed: in the process of development, the gelatinous chorda dorsali becomes enclosed in a membranous sheath which at length becomes fibrous, being composed of transverse annular fibers; though it never itself passes into the cartilaginous or osseous state, but is encased within the persistent part of the column which are developed around it, it is to be regarded as the intervertebral and of the spinal column. The cartilaginous or osseous vertebrae are first developed in the condition of a coat of minute opaque plates presenting a series of quadrangular figures at the sides of the chorda dorsali, imbedded in ridges on either side of the central groove, and constituting the arches of the rudimentary vertebra. These gradually increasing in number and size incline toward
each other, and at each juncture and ending in the groove, complete the cylinder for the protection of the cord. This however is not the ease towards the anterior extremity, and the large cells in which the great divisions of the inca phalanx originate may be seen between them. The chorda dorsalis, in the animal where it is not persistent, now gradually fades and at last disappears, before which the suspension of the bodies and arches of the vertebrae begins at distinct points. In the case where it remains through life, the lateral elements of the vertebrae undergo no further development. In the ruminant fishes the spinal column parts as segmentation, and here ends only the chorda dorsalis with the fibrous capsule surrounding its sheath, forming superiorly the membranous covering of the vertebral canal, and being the large in which the skeleton originates.

In the human embryo ossification of the vertebrae is first observable about the 9th or 10th week and generally commences first in the neck; the osseous particles appearing on each side, and increasing forwards and upwards towards the body, backwards and downwards towards the spinous, and out-
towards the transverse and articular processes. The
ossification of the body commences in a single granule in the
middle of the cartilage. This is the centre of ossification
in the greatest number of the vertebrae; five epiphyseal
bony areas are added, but in this rule there are, as we shall
see, exceptions. At birth the 3 primary pieces are se-
parate, but begin to join during the first year of life; the lateral
pieces first join behind, in the third year; the arch is formed
first; in the centre of ossification of the body, and indeed at each
and every extremity helps to form a small part of the body.

The epiphyses of the transverse and spinous processes
are formed soon after puberty, and about the age of twenty.
Suture of the upper and lower surfaces of the bodies of the
vertebra, which finally complete the bone about the 5th or
6th year. The ossous structure is completed, which differs in the
two constituent parts of the vertebra, that in the arch
being compact, while the body is spongy, and contains many
vicious canals radiating from the foramina on the post-
caudal surface. The exceptions to the above general
rules as to ossification of the vertebra occur in the first
the cervical (Atlas & axis), in the 7th of the same kind, and in the lumbar, sacral, and coccygeal regions. In the Atlas, the ossification of the lateral processes commences early, but that of the anterior part of the bone rarely before birth & frequently by 2 or 3 cent. The lateral processes also join each other and the body at a later period than is the case with the majority of the vertebrae. There is a small epiphysis for the spinous process. The anterior portion of the axis is formed from 3 centres of ossification, one for the lower part of the body and two for the upper and a large process (odontoid) on its summit, the three uniting about the fourth year. In the 7th cervical vertebra a separate centre of ossification is formed for the anterior root (articular) of the transverse process, which as a rule subsequently unites with the true transverse process to enclose a small synchondrosis, sometimes however forming a separate bone. The lumbar region exhibits distinct ossous nuclei for the tubercles on the sup-articular processes. The process of the first is sometimes also developed from a distinct centre. In the sacrum, the arches join the
bodies of the vertebrae of the vertebral arch then join below upwards the process being completed about the 20th year. The lateral portions have separate centers of ossification appearing about the 7th month from above downwards, they join the bodies and arches of their respective vertebrae between the 8th and 9th years, and about the 18th stand to form the solid bone. Two epiphyses are connected with each side of the Saccus, one to the upper three, the other to the lower two segments, and may be considered as the conjoined epiphyses of the processes before alluded to.

The coccygeal vertebrae, in which ossification commences about the time of birth, usually possess one center each, or dividing from above downwards, the segments subsequently joining each other in the following order; the 1st and 2nd, then the 3rd and 4th, and lastly the 2nd and 3rd unite, the whole eventually becoming connected with the Saccus.

The arches of the Vertebrae taken as a whole ossify from above downwards; in the bodies the ossus matter is first deposited in the lower dorsal region, and thence proceeds in both directions to the top and bottom of the column; the ossific
process advances most rapidly in the larger vertebrae, i.e. in the lower lumbar. The sources of uncertainty will chiefly be the prime periods of ossification are principally

I. The difficulty of ascertaining the exact age of the embryo.

II. The difference which occurs in different cases in the growth of bone, dependent on the quality of nutrition.

A knowledge of the "Vertebrate archetypus" is essential to a complete knowledge of osteology, of which science it may be said to constitute the grammar, and it is now an universally admitted fact that the skeleton of all vertebrate animals is constructed on one common plan, however it may be modified to meet particular requirements. I propose them in connection with the present subject.

3. To make a few remarks on the typical vertebrae of Owen, and the general homologies of the Vertebral Column.

The vertebral segments which compose the spine are defined by Professor Owen to be natural groups of bone constituting the axis of the body, and the canals for the protection of the nervous and vascular trunks; each segment
a vertebra is further considered as consisting of a "centrum" or body from which certain processes or "apophyses" ascend and unite to form a neural arch, while others descend to form the hemal. The neural arches form a continuous canal, while the hemal are complete in some parts, but not in others; the former is the case in the dorsal region, where the ribs and thoracic bones combine to enclose the heart and lungs, and also in the pelvis where the hemal arches of the 1st and 2nd sacral vertebrae form a ilium for the fixation of the lower ex-
fractured and enclose the pelvic viscera. The absence or rarity
the rudimentary condition of the hemal arches is seen in the lumbar and ischial region.

The "typical vertebra" of man consists of the following parts:

1. Centrum or body
2. Hemapophyseal forming the sides of the neural arch
   A neural spine, its apone.
   2. Hemapophyses, forming the sides of the hemal arch
      A hemal spine, its apone.
& Pleurophyses, or ribs, one on each side the centrum.

2. Exophranous (out standing process)

4. Zygophranous, or articular processes, 2 of which are attached to the neural and two to the haemal arch.

2. Diaphyseous, or superior transverse processes.

2. Paraphyseous, or inferior ———

Each vertebra may have "diverse appendages" which in different animals serve different purposes, forming arms or legs, fins or wings according to their assigned uses. Vertebrae are subject to considerable modifications in the form, proportion, and composition of their component parts of all parts. The "centrum" is the simplest and most constant, for instance it is the only constituent of the basiventral vertebra in an animal tail; as we trace the chain upward we find the other constituent parts of the typical vertebrae gradually appearing, the most noticeable modifications being found in the back where the arch for the enclosure of the thoracic viscera is formed by the pleurophyses and haemophranous conjointly, the latter forming continuations of the former. (In the skull with some
remarkable modifications of vertebra present themselves, but upon these it is not for us now to dwell, suffice it that all the vertebral elements are present in a condition fitting them for the functions assigned them in that region. We shall see these features exhibited in examining the vertebrae of the different regions more in detail; and first the cervical; here we find in the two terminal segments nothing but the centrum of each, in the 3rd we find in addition rudimentary neurapophyses, and in the uppermost vertebra zygapophyses also, forming the transverse of the neck which unite with similar processes of the Sacrum. In the last several vertebra, and occasionally in the one above it, the neural arch is incomplete, in the upper vertebrae the neural arches from the edge for the origin of the neural spine; on each side of the ridge are the anchylosed zygapophyses, and the pleura and dia-pophyses also fused together from the "lateral mass". In the 1st and 2nd sacral vertebra the neural arches form the pelvic arch, the spines being the hemapophyses of the first and the Hickman part of the second, the Sclera is joined at part of the
gracily developed pleuropophyses. The other part is con- 

ected with the centrum. The hemal spine is repre- 

sented by the symphyses pubis. In the lumbar 

vertebrae, the transverse processes are present the pleuropophyses 

and are confluent with the diapophyses: two tubercles, 

anterior and posterior, projecting the former from the deep 

articulation processes, the latter between them is the transverse, 

are termed by Owen the meta- and para-pophyses. 

They attain a large size in some animals. The haem-

apophyses of the lumbar vertebrae are represented by the 

lines transverse of the abdomen, which are analogous 

to the abdominal ribs of reptiles. In the upper 

dorsal region we have the hemal arch well shown, being 

completed in the first 7 vertebrae by the coronal cartilages 

(hemapophyses shifted to the end of the pleuropophyses) 

and sternum which is the hemal spine. The arch in 

the lower 5 segments is incomplete. The diapophysis 

of transverse process is large to support the intercostal of the 

rib. The centrum, neurapophyses, neural spine and para-

pophyses are easily distinguished. The parapophyses are indi-
The vertebral column presents the constituent parts with simple modifications, the principal being the bony character of the neural spine, and the so-called transverse processes arise from two roots uniting to enclose a foramen; the ant-represent the parapophysis. The post-
the diapophysis or true transverse process, the two being connected by the pleurapophysis. Such is a short and very imperfect outline of this extensive subject. It is proved by a series of comparisons extending through all the vertebrate kingdom. The careful comparative anatomist finds no difficulty in tracing the same bone a part of a bone through all its modifications in the various members of the group, till he arrives at its simplest archetypal form. He recognizes the various elements in the spine of different animals as essentially the same though modified here and there, as they are adapted to certain functions. What if the bony arch is all but invisible in the human vertege, he finds it fully developed in the tail of the crocodile, where it is needed for the protection of the great blood-vessels. So the neural spine nearly
indistinguishable in some vertebrates? He points to the lumbar vertebra of the Ailuroidea where it stands forth expanded and prolonged into a long crest for the origin of the great pectoral muscles concerned in flight. Are the ant. and post. iliacs of the lumbar vertebra in the human subject but mere anatomical curiosities? He shows the former in the armadillo, as long as the ophioid process; and the latter, in the Lutita mamman, more conspicuous than the articular processes themselves. However modified to suit particular requirements, the "archetype" is never lost sight of, and may be traced at the bottom of all the modifications. Shall then so great a subject be thought but a tautological dozen? No, let Mr. de St-Cyry aver that "Il ne faut pas chercher à faire sortir l'histoire d'un système de métaphysique": even can still logically reply, "But a jaw is not the less a jaw because it is a "hemacyrd"; nor is an arm less an arm because it is a "dorsal wing appendage"."
We now, furtherly, proceed to an examination of the different portions of the column with regard to their adaptation to their peculiar use, and their modifications in the lower animals; and in so doing, I propose to examine each series of vertebra in detail, beginning from above.

And first from the cervical; the two first segments of this series present some striking features which deserve special notice. The Atlas, at first sight, appears to be wholly destitute of a body, a mere tubercle being all that is noticeable in the usual portion of the "centrum," but if we view this bone in connection with its fellow below, we shall then see, as has been imagined, that this body has been removed to make way for the odontoid process of the axis, but that this said process is the body itself of the Atlas, transferred to the second vertebra, and thus the Atlas really exists around its own body. The spinous process is reduced to a mere tubercle, and this is admirably necessary for the freedom of the backward movements of the head; here occurs one of the weak points in the vertebral canal,
and it is here that animals are usually "through." This portion of the spine is directed to the head of the vertebral, and at this point, guarded by the first portion of the half's head, enters the Foramen magnum, and the paraplegia of the head falls beneath the influences of the head. The united anterior and posterior processes project considerably on each side and thus give greater leverage to the inf. articular processes, which assist in rotating the head from side to side. The sup. articular processes are oval, concave from before backwards and high in their vertical axis so as to form a cap for the support of the condyles of the occipital bone, their shape is adapted to permit the nodding movements, and they are advanced in order to support the weight of the head and transmit it in the line of the bodies of the succeeding vertebrae; owing to this the vertebrae in the aires are behind the sup. articular processes of this bone, while in all the other vertebrae they are in front. The inf. articular processes are flat and nearly horizontal, so as to slide in the movement of rotation.
on the top articular processes of the occi. The neural arch is wider than in the oter vertebra allowing ample space for the spinal cord, indeed in the sp. of the Med. Chi. Tuna. a case is related by Dr. Pugh of lateral dis-placement of the atlas without compression of the cord. In Reptiles the first several vertebra possess a cavity into which the single articular process of the cephalad bone, sometimes divided into 3 parts by a narrow space or into dental facets, fits, and in Birds the articulation is also formed of a single condyle, a sort of semi-circular pivot placed in the dorsal line of the body, and receIVED into a corresponding articular cavity in the atlas, a much greater degree of motion being thus permitted than in the case of Mammals.

The Occi. The identical process, the pivot on which the head with the Atlas turns, being vertically from the body of the Occi. fits into a kind of socket formed in part by the Atlas and completed in the recent state by the transverse ligament, which latter is enabled to clasp it more securely by a slight constriction forming 'the neck.
of the process, and it is further secured in position by the "check" ligaments which fasten it to the occipital bone. Such are the arrangements for the fixation of this important process, but it nevertheless does occasionally slip out of the way, this accident being more likely to occur in children from the greater weakness of the ligaments, but it has happened in the adult, in a case for instance where a child while being carried on its mother's shoulders, lost its balance, and clanging to her head, drew it suddenly backwards; the instant death of the mother was the result. So Henry is the intimate structure of the occipital process that it is probably rarely, if ever, broken. The two articular processes of the axis resemble the two ones of the atlas and are adapted to the stationary movements, flat and nearly horizontal, if have a very strong ball, since they, and not the body of the bone, support the weight of the head. The inf. articular processes are alike, and have the same size and position as in the vertebrae beneath them. The conjoined processes with the sinuses for the vertebral artery are inclined obliquely
outwards to suit the curve which is necessary for the
vessel to reach the for outstanding frame of the skull.
The spinous process is very large and projecting for the
same purpose as in the case of the processes of the skull:
i.e. the attachment and leverage of the elevating muscles
of the head. With regard to the rest of the cervical
vertebrae, the bodies present lateral ridges fitting into
corresponding depressions in the vertebra above, so as to prevent
lateral displacement. The spinous processes are short
and horizontal to permit the free extension of the neck.
They are bifurcated at their summit, an arrangement
peculiar to the human skeleton; the object being the
allowance of space room for the insertion of muscles
maintaining the neck, and therefore the head, erect.
The spinous process of the 7th is however not bifurcated,
but very projecting (vertebra prominens) to give addi-
tional leverage to the ligamentum nuchae and mus-
cles; the combined lateral processes of this vertebra enclose
but a small frame, possess but a slight groove above,
and only a trace of bifurcation at the summit, whereas
in the upper vertebrae of the spine the groove on the upper surface of the processes bifurcates their summit, so that two tubercles are formed, and 3rd post. for the attachment of muscles, the antt. tubercle is very large in the 6th cervical vertebra, and it called the cervical tubercle, being a guide to the carotid artery. A peculiarity in this regard to the ossification of the 7th cervical vertebra must still be omitted; its parapophysis is usually formed from a distinct second center. The point of ossification appearing about the 2nd (Böeckel) or 3rd (Quain) month, and uniting to the rest of the bone about the 5th or 6th year. Sometimes this process continues as a separate bone, and then forms what has been termed a cervical rib.

And now to glance at some modifications of this scale in some lower animals; and first as to the number of segments composing it; in this particular, among the Mammalia, there exist as before remarked a singular constancy, being the number in all known Mammals, except the Three-toed Sloth (Bradypus tridactylus) which...
has two more, and the Granulate or sea-cow which has
less than 7. In the whale, which appear to have no
neck, there are as many cervical vertebrae as in the Giraffe,
a striking instance of "unit of type" within the limits
of a class. In birds the neck is generally much longer
than in Mammals, and the more so the higher They are
elevated on their legs, the jaws being the principal organs
of phagisation; in the Swan the neck exceeds the height of
the body, thus enabling the bird to seek its prey at con-
siderable depth, while swimming. The usual number of
cervical vertebrae in birds is from 12 to 15, but there are
sometimes fewer and occasionally as many as, or more than
twenty. Among Reptiles the cervical portion of
the spine is that in the Ophidia, and less in the Chula-
nia. In either it is usually very indistinct. The
articulating surfaces of the cervical vertebrae in Birds are
to more hind and concave in front, and thus capable
of great freedom of motion; in the upper part of the
neck they allow of flexion forwards, in the middle only
of flexion backwards, and again towards the base of the
neck only of anterior portion: this peculiar arrangement enables the neck to describe abrupt curves, and in most birds it is held more or less in the form of an S, thus being the most favourable position for suddenly darting forward the head, a movement employed by many in the capture of prey. The fleshy processes in birds are strong; in the intestine they are absent, the creature being thus enabled to retract the entire neck within the carapace. The existence of cervical ribs in the snakes is a striking testimony in favour of the osteocone theory, they are used as organs of locomotion in conjunction with similar appendages to other parts of the column. In crocodiles too the cervical vertebrae are furnished with rib-like processes, which however instead of assisting, rather tend to interfere with the process of locomotion, at least as regards the movement of turning on land, so that they may easily be escaped by doubling. In the Pons (Piscis) of whales (Mammalia) the cervical vertebrae are not movable one upon another, thus affording a firm support
to the head in movements through the water.
The vertebrae of the dorsal region, 12 in number, are char-
terized chiefly by their immobility. Their bodies present
much less difference between the anterior and lateral
diameter than in the case in the other sets of vertebrae, and
are very convex on their anterior surface with considerable
prominence. This being particularly noticeable about the fourth
segment of the series, on them are articulating surfaces for
the heads of the ribs. The articulating processes are nearly
vertical, the inferior looking backwards, the inferior
his mode of articulation prevents any bending of the
spine in this region, as do also the spinous processes
which are large, indented, and directed almost directly
downwards; an arrangement which with the breadth
of the plates also renders penetration of the canal im-
possible at this part. The transverse processes (stap-
acies) are long, thick, and inclined backwards, and
with the exception of the two lowest possess articulating
surfaces for the tubercles of the ribs. The foramen for
the cord is small and circular.
Taking the dorsal vertebrae of mammals generally, they may be said to be distinguished from the cervical by the production of spinous processes for the attachment of ligaments, which are of very large size in species with long necks or heavy heads; and by the surfaces for the articulation of ribs; their number is variable, as is also that of the ribs, some species having only 11, others as many as 20.

The additional vertebrae of the cervical region in the lovers above-mentioned may in reality be regarded as dorsal in which the ribs do not reach the sternum.

In birds the dorsal vertebrae are usually 8 or 10, but vary from 6 to 11; they are short, broad, and all unsegmented or only slightly united, the sides of the wings in flight assuming a point d'appui, and that this is the essential purpose of nature in this curious union is shown by the fact that these vertebrae are distinct and mobile in birds which do not fly, as the thrush and canary, they are furnished with spinous processes on the lower surface projecting into the cavity of the body and giving support to the wings; they have also a dorsal spinous pro...
con for the attachment of muscles, and transverse processes to which the ribs are articulated. The latter are flat bones uniting by a movable articulation with a pair of dorsal ribs which are analogous to the costal cartilages in other animals, and each of which for stability has a laminar process passing obliquely upward and backward and attached to the following rib.

Among Reptiles, the order Chelonia exhibits many modifications of the dorsal vertebra; when viewed from beneath, the central line of the carapace is seen to be composed of the bodies of the vertebrae, on each side of which are the broad flattened ribs usually 7 in number and attached to each other by dentated sutures, in some instances however having considerable spaces between them towards the margin of the carapace. Internally in the visceral line we find the flattened spinous processes taking part in the formation of the true plastron (2nd to 7th).

In Turtles, the principal point to be noticed in the dorsal region is the existence of the interpygal bones which rested on the spinous processes of the vertebra.
Some members of the order Sauia (Reptilia) are remarkable for the elongation of the spinous processes of the dorsal vertebra which support a broad membrane running along the back, having the appearance of a broad perpendicular fin.

The lumbar vertebra, 5 in number, are larger than either the dorsal or the cervical, becoming broader as they descend to form a base for the support of the column. Their general characters are as follows: the bodies large and oval, with the broad diameter from side to side, for the better support of the trunk. The spinous processes are large to afford extensive leverage for the extensor muscles of the column, and from their horizontal position do not interfere with the extension of the back. The articulating processes are large, the two superior concave looking inward and a little backwards, the lower convex looking outward and a little forward, which arrangement admits not only of flexion and extension, but also of a degree of rotation, useful in progression. The last lumbar vertebra is distinguished by the shape of its under surface; by
The thickness of its own bone process for the attachment of the sacro-vertebral and the lumbar ligaments, by the large space between its inter-articular processes to form a broad base of support; and by its smaller spinous process which does not interfere with the flexion-extension necessary at this point.

The 5 vertebrae (sometimes as many as six, or as few as four have been found) composing the Sacrum have been already generally noticed above, among the homologies of the column; the single bone they form is inserted between the two one innominata dorsal to form the back bone of the arch which supports the spine, and transmits the weight to the lower limbs. It inclines backwards and forms with the last lumbar vertebra a rounded angle, (promontory) increasing the space in the pelvis, and giving the face of the bone from pelvis to spine. With regard to its position as a keystone, it is broader below than above and tends to fall, now the keystone of an arch is generally broader above than below, that...
And could so fall forward in consequence of the position of the joint; but any movement of the hand is prevented by the sacro-iliac ligaments, and the greater the weight upon the 5th lumbar vertebra, bending as it apparently does to keep off the Sacrum, the less do the two lumbar ligaments become, the closer are the one innominae pulled together, and the more firmly is the Sacrum jammned between them: to admirably deal the apparent insecurity of this portion of the spine constitutes its real safety.

**Difference of Sacrum in sexes.** It is difficult to decide in the case of a single bone whether it is a male or female sacrum, and the statements of anatomists are most contradictory on the point. The chief differences appear to be, more regularity and smoothness of surface as well as greater breadth in the female Sacrum, and it seems to stand more from the cavity of the Pelvis, an
arrangement evidently adapted to the faculty of 
rotation in the bone.

Among the other Mammaliae, the Sacrum is usually
formed of 5 or 6 vertebrae, but is entirely wanting in the
Cetacea, where indeed the four support is given the pelvis
is not needed, the pelvis itself in these creatures being
completely detached from the vertebral column. In
The Chimpanzee, the Sacrum has only the two first
lumbar vertebrae fully developed and united to the
diaphragm, hence the trunk is less firmly connected
to the pelvis arch, and therefore needs additional
support from the arms. In Birds, the lumbar
and dorsal vertebrae, which vary in number from 7 to
from a single long piece, the only indications of its
compound structure being the foramina for the trans-
mission of nerves, and with this elongated Sacrum
the pelvis arch is also amalgamated. The lumbar
portion is occasionally furnished with its own
the true ribs in structure, but wanting the carnivore process.

In the Dinosauridea (reptile ancestors) in the pelvic


and colonic formations). The sacrum consists of 5 amalgamated vertebrae, a structure appearing in mammals but in no other reptiles. In snakes only 2 vertebrae join to form the Sacrum.

The vertebrae, as a rule, number, forming the coccyx in the human subject constitute the caudal portion of the spine, adapted in man to the assumption of the sitting posture, which is to peculiar to him. The segments are, as before stated, reduced to an extremely rudimentary condition, little else than "the centrum" being distinguishable. The highest indeed possess two small superior articular processes (cornua) for articulation with the Sacrum, as well as two rudimentary transverse processes; and two tubercles, one beneath each cornu of the dorsal spine. The last decrease in size downward, giving the entire bone a triangular shape; the bones are united by fibro-cartilage allowing of flexion backwards and forwards, which is useful in particular, and gives as much as an inch to the antero-posterior diameter of the pelvic inlet. About the age of 15 or 20 particular
in persons of sedentary habits, the parts of the bone become ankylosed to each other and to the Sacrum, forming one of the causes of difficult labour in women. This bone indeed sometimes fracturing during parturition, has also been urged as a cause of difficult labour from this cause are common in females who ride much on horseback. This has been stated to be the case among the Aborigines, where the women indulge in great extent in equestrian exercises. Instances of unusual elongation of the coccygeal portion of the spine in man have been mentioned, but are of doubtful authenticity. Among the lower animals so part of the column is subject to greater modifications, particularly as regards the number of vertebrae segments, in some, as in that of the genus Icterus, the guinea-pig (Cavia aperea), and others. There exists no tail whatever; in other mammals there are as many as 40, 50, or even 60 coccygeal vertebrae, and in these we also find this distinction, that the canal for lodging the spinal marrow and a portion of its nerves still exist in some of these bones, while in the
Among the more remarkable varieties in respect of form, may be noticed the large-tailed sheep of Western Asia, in which the appendage is enormously increased by an accumulation of fatty matter, so that it sometimes weighs as much as 70 or 80 lbs.

The uses of the tail of Mammals are chiefly two, locomotive and preliminary; with regard to the former we have some remarkable instances: in the Kangaroo, for the long and thick tail becomes, with the hinder limbs, a sort of tripod, and hardly assisted, the animal in its leap, is intended in a straight line, acting as a counterpoise to the anterior part of the body, and supporting the creature when leaping from its leap, swing the curvature of the latter described thus: When their feet have been shortened at different lengths, it has been found that their leap, which sometimes is said to be so great 25 ft., with an elevation of 6 or 7 ft., is diminished in the same proportion, and when it is wholly cut off, they cannot leap at all. The tail of the Echeneis, which...
is in the shape of the caudal fin of fishes, and when folded, but placed horizontally, contains a firm cartilaginous or even ossous spine, which appears like the judgment of lower extremity, covered with a tendinous skin, and enables them, by an up and down motion, to sink to a great depth and rise again to the surface with great rapidity; and the strength of the caudal fin is a just object of terror to the Arctic whale, a boat and its crew being too often landed into upper air by one blow of the prodigious appendage; beneath the body of this caudal ventricle we find the bones shaped like the letter V, which seems to serve as aids to strengthen the flesh肌肉.

As a prehensile organ, in fact a fifth hand, the tail is used by the American monkey for clinging to branches of trees, for swinging themselves from one to another with the greatest rapidity; this prehensile power of the tail forms a distinguishing characteristic between the monkey of the Old and New Worlds, that of the former rarely if ever using the appendage (which indeed is often absent) for the purposes abovementioned, much as the illustration
If Dr. Chalmers' work could lead us to imagine the century in which the old world Quadrumanous are represented danging from the tree by their caudal appendages with a total disregard of the facts of natural history. So powerful yet delicate in the tail of the Spider Monkey (Ateles) that the animal often supports the whole weight of the body upon it alone, and is said even to pick up small objects with it. In animals which like the Flying Squirrel (Pteronyx) possess a broad fold of their along each side forming a kind of parachute in their leaps from tree to tree, the tail acts as a kind of rudder; as also in the feline race in whom, when they spring upon their prey, it is extended stiffly in a straight line, as if to guide them to the object they have been watching from their lairs.

It has been affirmed that Bravos (Lactia Yata) employ their tail as a brand to plaster their houses, and as a help to carry the bees they feel, but these assertions seem to be built rather on conjecture than on observation. The tail in these animals being partially rud
used as a natatory organ. Such are a few of the
most interesting instances of the use of this important
appendage in Mammals.
In Birds the tail is very short, and composed of
from 6 to 9 small vertebrae, which are capable of a small
amount of motion and furnished with strong transverse
processes. The last vertebra is considerably larger than
its fellows, of an oblong form, and set on in a direction
nearly perpendicular to the axis of the body, it gives
attachment to the muscles which move the feathers
of the tail, and is consequently of great importance.
In Reptiles the tail is long and flexible serving both
for preservation and for locomotion in their various modes
among the Salamandria the Amara (Sph. Bats. 10) have
no tail in the adult state; the Plethodon (Salamandria) in
the contrary, possess it. In Fishes the ossiculi
formed by the processes of the dorsal portion of the skull
for the protection of the spinal marrow is repeated.
Beneath the clavus in its caudal portion, it lodges
the great artery of the trunk: the bony arch is well
formed by "transverse processes" at the "parapophyses," which bend down, meet, and are prolonged to and form a transverse spine. Each has a jugapophysis at its base.

Curves of the Column. When viewed in profile in the natural state, it presents an curve, depending except the neck on the thickness of the intervertebral substance in the different regions. At least, rich in the use in the neck of curve, in the dorsal region it is rather varying to the shape of the bones. In the neck the convexity looks forward, adapted to the erect attitude and characteristic position of "the human face divine." In the back, the convexity is in the opposite direction allowing room for the spine, the advance in the lower extremity in the support; in the pelvis the convexity is again backwards the final curve being adapted to the sitting position of man, and the passage of the child's head in the process of parturition. A slight degree of lateral curvature is noticeable in the cervical region, about the neck of the vertebrae, with the concavity on the left side.
This has been attributed to the action of the limbs, but Reichart and Bécourt have traced it to the effect of muscular action, the convexity being toward the right or left side according to the hand chiefly used by the individual. In the spinal column of the infant, the curves are less distinctly developed, and their alteration in the aged enables us to see free of the pelvic cavity from the front. The curves of the spine make it stronger, and better able to bear and defray shocks, and more alternately so as to distribute the weight ad vantagiously with regard to the line of gravity. This line passes through all the curves, and falls exactly in the center of the base. Finally, they give to the body that graceful form which has been the test of beauty in every age.

Movements. Flexion and Extension, as well as lateral movement, of the spine are fixed in the neck, less free in the loin and back in the back. To these degrees of mobility the articular facets are adapted; in the neck the articular processes being oblique, the Spines
short and horizontal, in the dorsal region. The articular facets are vertical and the spines inclined to the back again. The articulations of spinous processes continue to allow a greater degree of mobility here than in the neck.

The intervertebral substance, which does not exist between the two first vertebrae, forms about a fourth of the length of the movable portion of the column, but is not equally distributed in the different regions. The dorsal has, compared with its length, a smaller proportion, and accordingly less pliancy than the neck and lumbar. The dorsal moreover are all uniform in thickness in front and behind, and to this in the cervical and lumbar regions are due the curves of the spine. They are composed of an external laminar and a central soft and pulpy part, which when the pressure which confines it is taken off by cutting through the intervertebral substance, rises up so as to assume a conical form. It is yellow,
The in colour and contains much water, its structure is fibrous, cartilaginous. The fibres of each plate of intervertebral tissue extend obliquely between the vertebrae, their direction varying from large to layers, an arrangement allowing of some amount of separation of the vertebrae.

In most fish, the arrangement being well seen in the shark, the bodies of the vertebrae are followed out before and behind into conical cavities, the spaces of which usually meet in the middle of the vertebra; these cavities containing the intervertebral substance in an extremely fluid form, are adapted to allow of free and extensive movements. The great elasticity of the intervertebral substance breaks the force of jar by gradually yielding, and always tends to restore the column to its exact form. Long continued pressure during the day produces a yielding of the intervertebral substance, so that a man loses in height 3 or even 5 an inch, but this is recovered by a night.
A habit of leaning too much to one side will occasion under the yielding of the substance permanent, and thus distention may be produced without actual disease. The state of health and constipation appears to influence the intervertebral substance to a great extent; disease and emaciation producing a considerable diminution and consequent decrease in length of the spine; it is said that a gigantic philosopher, who in fighting condition measured 7 ft., at death measured only 6 ft. 7 in.

Concerning the other ligamentous structures of the spine little need be added. The anterior ligament prevents too great extension of the column, and is thickest in the dorsal region, concurrent with the immobility of that part. The supra-epi-epicrural ligament from the seventh cervical vertebra to the sacrum is largest in the lumbo-sacral region, and inseparable, binding in conjunction with the posterior common ligament.
Movement of Stenon. The yellow elastic ligaments from lamina to lamina, and the ligamentum sacrocoxae assist in maintaining the body erect; the latter is far more developed in the lower mammals for the purpose of supporting the more dependent head in these creatures.

Thus then have we but too briefly studied the wonderful mechanism of the vertebral column, a structure which cannot fail to excite the admiration of the greatest anatomist from the beauty of its arrangement and the many and seemingly incompatible efforts which it saves. As a column, at once strong and firm it serves to support in man the erect position of the body, and in all the vertebrata flexible to admit of the bending of the trunk in various degrees, and elastic to prevent concussion of the head. Finally, it protects the delicate spinal cord and forms a basis for the origin of muscles which
maintain the body erect or move the upper extremities. To whatever kingdom of Nature's vast domain we turn our gaze, and whether the inhabitants of earth, sea, or upper air invite our attention, there among the living beings that people each to we find proofs of the admirable mechanism of the vertebral column. The monarch of the vertebral series directing the sight to his watery domain with man himself; the boa-constrictor coiling around his enemy victim and winding it into a shapeless mass among his prodigious folds, proclaim its power; while the graceful flight of every biped of the grove, and the glittering sheen of the sea, wondrous of the ocean as he dare from his rocky covert, tale us of its firm yet elastic nature. And must of all in Nature's masterpiece, the human form, does the perfection of the structure depend upon its supporting column; true in the graceful contour of woman's form like oak,
And in the background before of the mantle flame, shines the full splendour of the fabric, an admirable blending of strength and beauty, forming one of the most striking of those instances of design in creation, on which the natural Philosopher loves to dwell.