

Lecture II

The Skeleton

1855



Descriptive Anatomy usually commences with the Bones, and ~~this is agreeable to the sequence~~ the consideration of the passive organs of motion before the active ones is conformable to the sequence of development, since the fixed points are formed before the muscular fibres.

The branch of Anatomy which treats of the skeleton of Vertebrate Animals is designated 'Asteology', because in anthropotomy it ~~applies~~ ^{relates} exclusively to the bones & teeth. But the skeleton, ~~in its~~ ^{according to its} etymological signification of hard and dry parts, ~~applies to include~~ ^{might apply to} the hair & nails, and indeed, the entire epidermal system: when, also, we call to mind such homological relations as that of the fibro-membranous sclerotic of the human eye with the cartilaginous sclerotic of the Turtle and the osseous sclerotic of the ~~cod-fish~~ ^{cod-fish}, ~~we shall see reason for~~ it will be obvious that the present branch of Anatomy ought naturally to ~~include~~ embrace the aponeuroses, ligaments & cartilages, since these are so many arrested stages in the histological development of the internal skeleton.

In the

in a general survey of the Vertebrate, we see the spinal column ~~and~~ strictly in some fishes, and the tendons long in some birds, and when

And we find that all knowledge of the working of the system is the result of the study of the system.



Notes
- 4 -

For the sense in which the terms homologous
& analogous are used in the present
lectures, see the Glossary appended to
the "Lectures on Invertebrates." 8th 1843.
~~and Philosophical Magazine, May~~

Lecture II. On the Skeleton.

The branch of Anatomy which treats of the Skeleton of Vertebrate animals is designated 'Osteology', because, in ~~anatomy~~ osteology, it applies almost exclusively to the bones and teeth; although the Skeleton, in its primitive etymological signification

of ~~dry and hard & dry parts~~ ^{include the hair and nails} ~~ought to include the entire epidermal system.~~ ^{including the entire epidermal system.} ~~the branch of anatomy which treats of the present~~ ^{the present branch of anatomy} ~~the relations of homology & points indicated that the present branch~~ ^{the present branch of anatomy} ~~the aponeuroses, ligaments and cartilages~~ ^{since there are so many arrested stages} ~~in the histological development of~~ ^{the internal skeleton} ~~the internal skeleton~~ ^{we saw that}

In the Invertebrata ^{we saw that} the Skeleton, or parts analogous to the bones of the Vertebrata commonly consisted of large, strong, thick, ~~sometimes~~ ^{often} unjointed plates, developed in or upon the skin, hardened principally by carbonate of lime, protecting the whole body and ~~giving attachment~~ having the muscles attached to the inner surface.

In the Vertebrata the skeleton chiefly consists of ~~solid~~ ^{(cylindrical, but} ~~diversely~~ ^{but most commonly} configured and articulated pieces; hardened chiefly by phosphate of lime, developed from fibrous & cartilaginous tissue in the interior of the body, of which it forms the internal framework; giving attachment to the muscles by the outer surface and ~~aiding~~ ^(subservient) their action as levers and fulera. In external

The external calcified shells and crusts of the Invertebrata are unvascular: they grow by the addition of layers to their circumference; or ^{they} may be cast off when too small for the growing body, and be reproduced of a ~~larger~~ ^{more conformable} size; but they have no inherent power of repair.

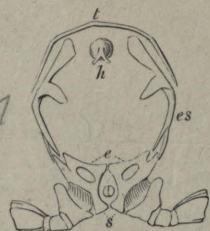
The internal bones of the Vertebrata are vascular; ~~and~~ ⁱⁿ ~~general~~ they grow by internal molecular addition & change, and have the power of repairing fracture or other injury.

Such are the broad & obvious ^{distinctive} characters of the skeletons of the Invertebrate and Vertebrate Animals: the contrasts having relation ^{chiefly} to the difference in the development of the Nervous system. Thus, when the powers of discerning and avoiding lethal or hurtful agencies are dull, ^{& contracted} the entire animal is protected by a hard insensible dermal ^{armour} or 'exo-skeleton'; but, as these powers become expanded & quickened the body is disencumbered of its ~~armour~~ ^{coat of mail}, the skeleton is put inside, and made subservient to the activities, and the skin ^{becomes proportionally more} ~~more~~ susceptible of impressions of pleasure and pain.

Some estimable Anatomists, who have more especially devoted their attention to the detection of ^{corresponding} ~~parts~~ in different animals, have ^{proposed} ~~believed~~ that these different functions were performed by modifications of (the same essentially) or homologous parts of the skeleton.

Observing

Fig. 6



Segment of exo-skeleton, Segment of
Astacus. Endo-skeleton,
mammal.

and the current Prof of Comp Anat
 in Univ College

speaking of the ^{skeleton of the} Pentapoda to Comp "We
 observed that the central rings which
 encompass the body, the segments of
 the body, or their vertebrae, &c.

(Lancet, No 543.
 p. 655.
 January 1884.)

- Then there is nothing new in the ribs of serpents serving
 as organs of propulsive motion, like the appendages
 developed from the hollow bodies of the vertebrae
 of Articulata. // Lectures

[Observing that a segment of the outer skeleton
 of an articulate animal, the thoracic ring
 of a lobster, for example, formed a ^(fig. 6)
 small canal ^(c, c') for the nervous trunks, and
 a larger one (h) for the vascular trunks and
 plastic organs; and that a thoracic
 segment of the skeleton of a Vertebrate
 animal ^(fig. 7) also formed a small protecting
 canal for the spinal chord ^(c, c') and a larger hoop ^(c, h)
~~loop~~ about the vascular and other viscera
 of that cavity; - they have concluded that both
 were modifications of the same ~~elemental~~ elements or pri-
 mary segment ^{for example, (No. I, p. 72)}
~~parts~~ of the skeleton. (Cuvier calls both rings,
 'vertebrae'; and Geoffroy ^(II, p. 119, pl. 7.) thought it needed but
~~signifying~~ to reverse the position of
 the Crustacean, - to turn what had been
 wrongly deemed the belly upwards, - in
 order to demonstrate the unity of organization
 between the Articulate & Vertebrate animal.

But the position of the brain ~~was~~ ^{is} ~~still~~ ^{is} thereby reversed, and the alimentary
 canal still intervenes ^{in the Invertebrate} between
 the aortic trunk and the neural canal.

[But] The outer and the inner skeletons ^{do} agree in certain
 relations: neither of them are primitive parts
 of the organism, but are modifications or metamorphoses
 of other ~~organs~~ ^{and} pre-existing systems.

Both serve as fixed points of attachment
 of the muscles, ~~and~~ ^{and} their action as
 levers; and determine the ^{kind} ~~direction~~ of the
 movements by particular joints.

(Both are ~~protecting~~ organs of protection & support.

[But] ~~they~~ differ in the one being developed from
 the exo- & the endo-skeletons

4 a

and conformable in number ^{with} the parts of
nerves ^{thence} sent off.

* "Numerus vertebrarum semper cum numero nervorum
spinalium in time coheret. " Otto Heer, 1836, p. 6

(number of neurospheres) - "Scapulum concretionem normali
He 4^{to} p.

the skin the other from the internal cellular & fibrous systems. ^{depends on}
 (The exo-skeleton surrounds the whole periphery of the animal; the endo-skeleton the internal parts.)

(The exo-skeleton is related to the muscular by its inner surface, the endo-skeleton by its outer surface. The differences of tissue, made of joint the & vital properties have already been noticed.)

(Part.) Even the so-called neural canal is differently constructed in the segments of the exo- & endo-skeleton selected for comparison. In the Vertebrates it is an arch developed from a central column ^(= p. 7), which, in like manner, gives origin to the opposite or basal arch. In the Articulata the neural canal is formed by processes, apodemes or entapophyses ^(= p. 8) sent off from the great peripheral arch. Moreover the condition of the development of these processes relates ~~more~~ rather to that of the muscular than of the nervous systems. ~~of the Articulata.~~

We saw how greatly the ganglia vary in number and position upon the abdominal nerve-chord-trunks of Insects. Now, if the entapophyses ~~(= p. 6, c)~~ of the dermo-skeleton — the secondary vertebrae of larvae — were developed like the neural arches of the vertebrae of the endo-skeleton, in special relation to the protection of the nervous centres ^{and}, we ought to find them governed by the existence and position of the ganglia; but it is not so. In the Myriapoda, as Van Baer well objects ^(III), entapophyses are

Thus a cartilaginous cranial vertebra coexists
in the highest Invertebrate with a
calcareous dermal skeleton:

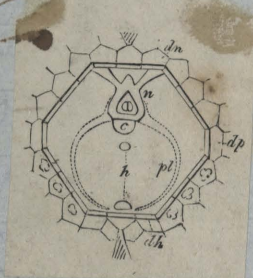
and there is no abrupt contrast in passing thence
to the ~~vertebrate series~~ as we enter into a new
~~series of the inferior forms~~
(consideration of the skeleton in
the Vertebrata.)

are entirely absent; and, in Winged Insects, they are confined to the thorax or ~~the~~ locomotive segment; although there may be 2, 3 or 4 ganglions in the abdomen. And, what is further to be remarked, the thoracic entapophyses are not developed over the thoracic ganglions, but over the intercommunicating chords. In fact, their relation to the nerve-trunks seems to be accidental, depending upon the position of the muscular masses to which they give attachment, and which office is the essential condition of their existence. For this purpose the processes of the exoskeleton of Insects & Crustacea must go inwards, and thus they happen to protect certain parts of the nervous system.

Only the highest of the Mollusca possess a true homologue of the endo-skeleton, developed in relation to the defence of the nervous centres: but it is a feeble cartilaginous indurment in the best organized Cephalopod; and, in the Fiddle-fish, is far outwighed by the calcareous dorsal plate which ^{still} represents the exo-skeleton of the ~~Crustaceans~~ Mollusks. Thus a ~~Crustacean~~ ^{by no means, indeed,} ~~is~~ ^{dispensed} with in this ~~vertebrate~~ series, although the endo-skeleton is constant, and ^{here attains} ~~reaches~~ its full development, and ~~is~~ ^{is} ~~generally~~ ^{is} ~~in the lowest class,~~ ^{in the lowest class,} ~~as in the~~ ^{as in the} ~~most~~ ^{most} ~~fishes,~~ ^{fishes,} ~~for ex.~~ ^{for ex.} ~~ample,~~ ^{ample,} ~~present~~ ^{present} ~~an~~ ^{an} ~~imbricated~~ ^{imbricated} ~~covering~~ ^{covering} of scales, developed, like shells, between the derm & epiderm: other fishes have ~~some~~ hard apicous plates or spines scattered over their exterior; or ~~some~~ ^{some} are entirely ~~unarmoured~~ ^{unarmoured}

as in the *Lepidosteus* and the *Ostracion*,
 which latter ~~fish~~ affords an most
 instructive example of the
 coexistence of an exo- with an
 endo-skeleton - & a ~~most~~ convincing
 refutation of the idea of the
 homology of the annular segment
 of the crust of the lobster with a true
~~vertebra~~ typical vertebra,

Fig. 4.



Segment of endo- and
 exo-skeletons, Ostracion.

In the subjoined diagram, ^{Fig. 5.} n is the
 cartilaginous neural canal, pl the
 membranous pleuraeophysical wall of
 the abdomen. h the arterial & venous
 trunks of the abdomen. dn, dp, dh the
 dermal ganoid plates.

surrounded by a connected armor of
 dense, enamelled ~~aporous~~ bony scales; &
 The ^{spined} ~~scutes~~ of the Crocodiles, and the
~~the~~ ~~testelated~~ armor of the Armadillos
 are examples of the exo-skeleton coexisting
 with a well-developed ^{topified} endo-skeleton,
 and wherever the exo-skeleton ~~differs~~ ^{is a} ~~the~~ ^{vertebrate} animal
 is calcified it presents the same organized
 vascular structure & vital properties as
 the bones within. Most commonly the exo-skeleton
 of the air-breathing Vertebrate is epidermal, as where
 it forms the scales of the serpent & lizard,
 the large plates of the Tortoise, the
 imbricated pointed scales of the Murex,
 the spines of the Porcupine, the Hedgehog,
 the quills of the Porcupine, the feathers
 of the Bird, or the hair of the ordinary Mammalian
 quadruped.

The skeleton is not entirely external & dermal in
 the Invertebrata. Independently of the true cartilaginous
 endo-skeleton of the Cephalopods, and of the
 entostrophyses, sometimes also cartilaginous,
 of the annular segments of the exo-skeleton of
 Insects & Crustacea, there are parts, as the
 calcified framework supporting the gastric teeth
 and giving attachment to the muscles which work
 them, in the Lobster ^{and the calcareous} gastric plates of the Buella,
 & the junctions of the internal ^{organs} ~~parts~~ or contained
 viscera; and we find a corresponding group of
 parts of the general skeleton in ^{most} ~~the~~ Vertebrate animals.

The cartilages ^{or bones} of the larynx, trachea & bronchia
 of the air-breathing Vertebrates; the bones and
 cartilages supporting the branchiae in Fishes,

and Batrachians, the bones in the hearts of certain Birds & Mammals, are examples of ^{of hard parts} visceral series, or ^{of} Splanchno-skeleton, as it has been termed by Carnus. And very nearly & naturally connected with this primary division of hard & dry parts are those bones and joints which form capsules or support the appendages of the Special organs of the senses; ^{for example,} as the sclerotic plates of the eye: the petrous capsule of the labyrinth; ~~and~~ the opicula & cartilages of the tympanum and external ear: the turbinate bones and joints of the nose.

But ~~that~~ some of these 'sense-capsules' are ~~connected~~ connected and intercalated with the true bones of the endo-skeleton, and subservient to similar functions, ~~besides~~ ~~forming~~ ^{besides} their own special ~~uses, so~~ ^{uses, so} that they are generally described as ordinary bones of the Skull.

As in all ^{arrangements} ~~classifications~~ of natural objects, ~~however~~ ^{where} ~~study~~ ^{is followed} Nature ~~is followed~~ ^{so in classifying the} in selecting their characters; ~~the primary~~ ^{the primary} ~~groups~~ ^{groups} of the Vertebrate ~~blend~~ ^{blend} into one another at their extremes, and make it difficult to draw a well-defined boundary-line ^{between them. Thus}. The hyoid & branchial arches closely resemble each other in fishes. Bones of the dermo-skeleton combine with those of the endo-skeleton to form the opercular and the single ^{median} ~~single~~ ^{on that account} ~~therefore~~ ^{therefore} ~~abandon~~ the advantage of arrangement and classification in ~~the~~ ⁱⁿ acquiring an intelligible ^{& tenable} knowledge of a ~~very~~ complex system of Organs, when typical characters clearly indicate ^{the} general primary groups.

O-O This difference depends chiefly upon the quantity of fluid, or
 evaporable matter, in the cells & tubes of the
 animal basis, but not wholly, as some have
 supposed; at least the apparently exact,
 & uniformly most carefully & scientifically conducted,
 experiments of M. Bilro, ⁽¹⁰⁾ on thoroughly dried
 portions, show the following differences:-/
 of time

Proportions #
 #

approximating

(very numerous & diversified parts)

~~It is~~ clearly, the existence of such characters in the
of the general skeleton of the Vertebrate Animals
~~(unlike the parts)~~ I, therefore, adopt the
primary division of these parts
into Endo. Skeleton, Exo. skeleton & Planchon-skeleton.

~~Part~~ The Endo-skeleton may present itself to our
observation under three histological
conditions, the fibrous, the cartilaginous
& the osseous: the exo- & Planchon-skeletons may
offer ^{also} another ^{or fourth} condition, viz., the albuminous
or epidermal.

The most ~~ordinary~~ common type of the
endo-skeleton of the Vertebrate is that called
'Bone', and it is peculiar to this primary
division of Animal Kingdom.

~~cellular and~~

Bone consists of animal, chiefly gelatinous, matter,
^{a general but regulated}
hardened by ~~the~~ diffusion of ~~inorganic~~ earthy
the proportion of organic & ~~the~~ earthy matter
varies in different classes.

Fishes have the least, Birds the largest
proportion of earthy matter;

^{stands, in this respect}
and, of the ~~intermediate~~ classes, ~~in this respect~~
the Mammalia, especially the active predatory
species, have more earthy, or harder bone,
than Reptiles. OO

~~Philp~~ [In the above
par. ~~The extent & kind of the bone vary in~~
~~this respect with the order by the following~~
~~table~~ ~~in which~~ it will be observed that
the bones of the fresh-water fishes are
lighter, ^{and} retain more animal matter
than those of the ~~sea~~ fish, which turn into
in

9a

00

Chemical composition of Bones.

	1 Hawk	3 Pottier	2 Morn	4 Cod
Phosphate of lime, with trace of fluor,	64.39	52.66	59.63	57.29
carbonate of lime	7.03	12.43	7.33	4.90
Phosphate of Magnesia	0.94	0.83	1.32	2.40
^{& Chlorate} Sulphat, and Carbonate of Soda	0.92	0.90	0.69	1.10
Glutini + chondrin	25.73	31.75	29.70	32.31
Oil	0.99	1.34	1.33	2.00
	<u>100.00.</u>	<u>100.00.</u>	<u>100.00.</u>	<u>100.00.</u>

in the denser ^{sea} ~~element~~; and that the
Mammalian marine species, ^{Delphinus} differs little
from the ~~sea~~ ^{fish} in this respect.

The Batrachian Reptile has more animal
matter in its bones than the Ophidian
or Saurian, and thus more resembles the
Fish. The serpent almost approaches
Birds in the ^{great} proportion of the earthy salts,
and hence the density and almost ivory-like
whiteness of the bones of Serpents.

The ^{typical} bones of Birds are the ^{whitest and} most compact
~~whitest~~ of all ^{bones} ~~animals~~, by reason of
their large proportion of earthy matter, and
also of the absence of marrow from their capacious
~~large~~ internal cavities, on which their
lightness depends. In these bones of birds from
which air is excluded the oily marrow
~~gives a deadness~~ the whiteness of the tissue, & it is often
~~difficult to get rid of the~~ greasy surface in skeletons.

The nature of the inorganic or hardening
particles and of the organic basis, according
to the analyses of Bibra, of completely
dried portions of bone, is exemplified
in the subjoined table, including a species
of each of the four classes of Vertebrata

100

In addition to the differences already noted
in the proportions of earthy and animal
matter, it is interesting to observe that
the ^{less soluble} soluble salts ~~are~~ ^{to the phosphates of lime} is
(proportion of) greatest in the Fish, and that there is most
carbonate

carbonate of lime in the bones of the Portnoie.

The quantity of evaporable fluid is greatest in the bones of fishes, especially in those of the semi-open ~~Blag~~ sharks ~~Blag~~ and Rays, in the skeletons of which, also, the salts of soda are in larger proportion than in the open fishes. In the entirely unossified skeleton of the Lamprey Bibra found only $1\frac{1}{2}$ per cent. of earthy salts.

The animal part of the shark's skeleton differs from the gelatin of ordinary bones and from the aspidiate cartilage of higher animals: it has more analogy with mucous, requiring 1000 times its weight of boiling water for its solution and this is neither precipitated by infusion of gallo nor yields any gelatin upon evaporation.

~~Development~~

we may next ask,

How are the inorganic earthy particles diffused through the animal basis and whence are they obtained?

Bones are not a primitive formation, but the result of a transmutation of pre-existing tissues. The ~~same~~ inorganic salts defined in the foregoing tables pre-exist in the albumen of the egg, in the Milk ^{which nourishes the new-born mammal} ~~in the~~ in the plasma or 'liquor sanguinis' of the circulating fluids.

The blastema or primitive basis of bone is not originally cartilage, but more resembles muscle in its chemical characters.

It appears at first to be a subtransparent glairy fluid, but contains a multitude of minute corpuscles.

As a premonition of the cartilaginous character of consistency is attended with the appearance in it of numerous small subelliptical nucleated cells.

As the cartilage hardens these cells ~~are~~ ^{increase} in number and size, and begin to ~~arrange~~ ^{accumulate} & to be arranged themselves in linear series at the part where ossification is about to commence. These series in the cartilage of long bones are usually vertical to its ends, ~~at this part a distribution from an adjacent~~ and, in ~~a pillar-like form~~ ^{flat bones} are ~~vertical to the peripheral edge~~ ^{vertical to the peripheral edge}: i.e. they are parallel to the axis of the long bone and are radiated in the flat one, but not ~~of course~~ ^{with} ~~mathematical~~ ^{mathematical} ~~exact~~ ^{ref.} ~~order~~ ^{order}.

The nucleated cells are the instruments by which the earthy particles are arranged in due order; ~~the~~ and, in bone, as in tooth, there may be discerned in this predetermined arrangement

the

the same relation to the acquisition of strength and power of resistance, with the greatest economy of the building material, as in the disposition of the beams and columns of a work of Roman Architecture. *P* (V, p. ^{vi} ~~2~~).

* Admits

Part i. 1860

p. vi.

Reichenow The power of the cells so separate upon the ~~early~~ ^{early} ~~particulars~~ ^{salts} of the plasma which percolates the intervening tissue seems to reside, ^{chiefly} in the ~~repulsive~~ ^{electric} property of their nuclei. ~~I have been led by the observation of some of the~~ ^{I have been led by the observation of some of the} ~~phenomena to~~ ^{phenomena to} ~~assume~~ ^{assume} that the walls & the nucleus of the cell were in opposite electric ^{or magnetic} states, one attracting, the other repelling the surrounding earthy particles.

Certain of the columnar series of nucleated cells, become more aggregated or packed together; their nuclei and, according to Miescher & Gerber, they become more coalesce and become dipolar. leaving concentrated, a cylindrical tube, parallel with the long axis of the future bone. First a reddish lymph, & ~~into these canals then a~~ ^{then a} capillary system of the ~~surrounding blood vessel~~ ^{capillary} is prolonged into each of these ~~canals~~ ^{cylinders}, which is thus converted into a "Haversian" or vascular canal. Before, however, the direct influence of the circulation has penetrated so far; the nucleated cartilaginous cells have ^{or propagated} arranged themselves in concentric series round the cylinder: and the intervening layers of the molecular blastema begin to be impregnated with the hardening salts: which, being repelled by the nuclei of the cells,

are

are forced into the concentric lamellar arrangement around the Haversian canal.

The establishment of the capillary circulation in these canals accelerates the progress of ossification by the rapid import of new material. The resisting nuclei, ^{of the surrounding concentric cells,} perfect on all sides, undergo a remarkable change, and the nucleolar matter is forced out in rays, ^{but} chiefly in the direction ^{where the resistance is least, viz,} towards the Haversian canal. The remaining nuclear matter ^{that of the diverging rays, finally become dissolved and} ^{central} ^{cells} ^{permanence bone - 2.} and minute tubes, which ~~are~~ ^{transmit} the concentric lamellae, open into the Haversian canal, and receive the transuded plasma from the ^{third.} capillary.

This system of cells and tubes, ^{in fact,} perform the same important function in the nutrition of the osseous tissue, which I ascribed, in 1838, to the corresponding cells and tubes of the cemental tissue of the teeth of the Megatherium, ^(VI, p. 106) and they might be appropriately termed the 'plasmatic system'. They correspond with ^{(for example,}

The tubes branch and anastomose. ~~tubes~~ ^{and} form the medium of the transpiration of the plasma through the densest osseous tissue.

one of the series of the Vasa lymphatica of the older Physiologists: the first, ^{kind specified,} in ^{Voquet's} Edition of "Kiel," quoted by Hunter. "les premiers naissent des extrémités artérielles: on les nomme 'artères lymphatiques', qui peut-être ne sont autre chose que les conduits excrétoires d'une lymphe très subtile ou de la matière qui transpire." ^(VII, Vol. ii, p. 11) ~~the first of the~~

central tubes of teeth and the plasmatic tubes of

~~"On the Cells of the Megatherium" Zoology of the Voyage of the Beagle, 6th p. 106. * (continued in p. 11)~~

indeed,

15.

of bone ~~are~~ are not, prolonged from
attenuated ends of arterial capillaries,
but ^{they} receive the plasma transuded or
transpired from the parietal pores of the
capillary system; ^{as they} they agree
~~with the system~~ in their main
physiological relations with
~~that the first class of~~ ^{the first class of} 'Koll' ^{Stromas'}
~~and~~ lymphatics. And the
solid tissues of tooth and bone manifest
~~under the microscope a~~
~~the~~ system of nutrient ~~tubes~~ vessels
which were only hypothetically
known to the older Physiologists.
I have detected a similar system
of plasmatic tubes in the tendon;
and they probably exist, under
characteristic modifications, in all
tissues, constituting the essential
nutritive system of each.

The remains of the metamorphosed
cartilaginous cells in bone were
first discovered by Parkinse and
Deutseh, ^(VIII) arranged in concentric
series around the Haversian canals;
they believed them to be solid and
and they called them 'corpuscula ossea'.
Meivianus first described them as cavities
or 'lacunae' in the intervals of the concentric
opified lamellae; he believed them to be filled with
fluid. Prof. Müller ^(X) was led by the whiteness of the
radiated corpuscles when viewed by reflected
light, and by its disappearance accompanied
with
Beiträge des organischen Lebens, Bremen, 1855.

15a

in a molecular state, molecules $\frac{1}{10}$ th diam of blood disc?

with evolution of gas when acted upon by Dilute acid I regard them as containing, either in their parietes or cavity, calcareous salts.

Serres & Dyere, & others have reproduced the idea of Meivianus, ^{which is true} ~~just~~ to a certain extent; but have erred in denying that the radiated cells contain ~~any~~ calcareous salts, and have objected to the term 'calcareous' applied to those cells.

But the effects of reaction of dilute acid in removing the opacity of the cell when viewed by transmitted light and ~~by~~ ^{in removing} its whiteness when viewed by reflected light, show that ~~these~~ ^{optical phenomena} are not due to the mere depths of empty cells. The fluids ~~which~~

~~percolating through them deposit aggregate particles of the earthy matter upon their parietes, and thus the cavities are preserved by the slow but constant percolation of the dentine, presents a two fold arrangement of its hardening particles, which are~~ ^{plasmatic fluids.} ~~either blended with the animal matter~~ ^{Others}

of the interspaces and parietes of the tubes & cells, or are contained in a minute and irregular granular state in their cavities." and "the density of bone as of dentine arises principally from the proportion of earth in the first of these states of combination." ^(V. p. iii) ^(V. p. iii) The primitive arrangement of this osseous tissue, so composed, is 'lamellar'; the lamellae being arranged either concentrically around the Haversian canal, or around the entire circumference of the bone

During

Structure

~~'Odontography', pt. i. 1860. p. iii.~~

(Nerve canal $\frac{1}{300}$ to $\frac{1}{500}$ inch in diam.)

§ the bones of Reptiles there is more diversity in the number of the Nerve canals, which is less in Ophidians & Serpents than in the fish-like Batrachians.

bone, is in interrupted plates connecting together the Haversian cylinders, and those with the generally surrounding peripheral lamellae.

The Haversian canals, ^{usually} contain, in addition to the capillary vessel, some oil, and this is the seat of the green colour in the bones of the Belone & Lepidosiren.

In most species of fishes, the nucleus of the cartilage all quite disappears in the progress of ossification, and only the tubular prolongations of the nuclear matter leave permanent traces, as plasmatic tubes, which traverse the osseous lamellae ~~of the~~ in the intervals of the vascular canal, & freely open into the latter, which are unusually numerous. In the ~~bones of~~ ~~Reptiles~~ ~~but are~~ ~~less regular in form~~ ~~and rather larger than in Mammals~~ ~~they are rounder in Birds, with less conspicuous radiating plasmatic tubes: they are usually~~ ~~more elliptical & compressed in Mammals, in the osseous tissue of which class~~ ~~the more appreciable difference~~ ~~in microscopic structure obtains~~ ~~in the relative size of the~~ ~~Haversian canals & the plasmatic caligerous~~ ~~radiated cells.~~

These cells vary little in diameter in different Mammalia; but the Haversian canals

which average $\frac{1}{600}$ th of an inch in diameter in the mouse, are $\frac{1}{300}$ th in diameter

in the

in the Ox and $\frac{1}{400}$ th of an inch
in the Human Subject.

The Nervous comals are fewer in the dense
fleshy type of Bird than in that of Mammals
Chelonia & Batrachia

In the bones of ~~Reptiles~~ they are more numerous,
larger, and more reticularly disposed;
the radiated cells are also larger.

in

~~In the~~

~~But in~~

In my treatise on the Teeth, I have ~~mentioned~~
~~the structure~~

shown that the osseous tissue corresponded
in microscopic structure with that of the
dentine in many places.

About
Haversi. 1840
p. XXII
p. XXIII. *Syme*

[In no case is the structure of the latter
more varied and in some, as we
find such extreme modifications
in that of the bones.

Throughout

In a great part of the skeleton of the Pike
the osseous, like the dentate tissue,
is characterised by "a reticulo-medullary
tubular structure:" the meshes or
interspaces being traversed by the
rich series of plasmatic tubes
communicating with the
the medullary vascular or Haversian
canals: and there are few
central dilatations ~~some~~

the radiating ~~the~~ plasmatic tubes, in other
words, few purkinian cells.

In this section of the lower jaw of
a *Muraena* we perceive, on the
contrary, ~~an~~ abundance of radiated
cells, but no Haversian canals.

The cells, divided lengthwise present
a long, thin ellipse, with the ends
prolonged into plasmatic tubes, larger
than those which radiate from the
sides

Atty General James A. Smith

sides; and, as the terminal prolongations communicate with each other, ~~the~~ a series of cells may be often be traced resembling a moniliform or alternately dilated & contracted canal.

In a section of a jaw of the common Eel, large, irregular vascular canals are seen combined with radiated cells like those in the *Muræna*.

In a section taken from the second thin longitudinal crest of the cranium of an *Ephippium*, there are no radiated cells, the dense tissue is traversed by parallel undulating plasmatic tubes, which here & there present slight dilatations, divide and give off minute tubes which anastomose in their interspaces. The medullary canals from which the tubes derive their plasma are few and large.

Almost endless are the minor modifications of the structure of the open type of the Vertebrate animals chiefly produced by varieties in size, course & number of the vascular canals ~~and plasmatic tubes~~, the radiated cells and tubes: ~~the~~ ^{both} vascular canals & ^{radiated} cells may be absent in the portion of bone examined, but the plasmatic tubes are always present. In the dermal bone-plates of the *Sargassum* they become, in the dense exterior layer

21a,

* The work of Bibra (No IV) contains good observations
and illustrations of the comparative
microscopic anatomy of the opeous
tissue in the different classes of Vertebrata. /

When the epiphyses finally coalesce the direction of the bone's axis
with the diaphysis' growth ^{in the} is at an
end: but /

the shaft, and are termed 'epiphyses', the shaft being the 'diaphysis': the seat of the active growth of the bone is in the cartilaginous crust at the end of the diaphysis. ~~But~~ in the mammalian bones, as in those of Birds & Reptiles, there is a slower growth going ~~on in the~~ on over the entire periphery of the bone which is covered by the periosteum.

The periosteum is that membrane in which the vascular system of a bone undergoes ~~the~~ ^{an} amount of subdivision which reduces its capillaries to the dimensions suited for penetrating the ~~bone~~ ^{bone} ~~after the vascular or haversian canals~~ pores leading ~~into the~~ to the vascular end

Conversion canals. (Nos. 190 - 201, Phys. series)

History { These preparations of the bones of young Pigs fed with madder, } (Nos. 188, 189)

I then ^{young} of Bird showing perforations of the bone ~~are~~ illustrate some experiments by Hunter on the growth of bone.

^{strong affinity} The ~~attention~~ of phosphate of lime for the colouring matter of the Rubia tinctorum, which, when taken as food, passes into the ~~serum~~ plasma of the ~~the~~ circulating fluids and combines with the phosphate of lime with which that fluid comes in contact, has been supposed to throw some clear light upon the growth of bone.

All the phosphate of lime which is deposited in tooth or bone, whilst the madder is in the system, is deeply ~~changed~~ ^{altered} by it

Journal

by it, and Hunter found ~~in the same~~
~~bone~~, that the exterior [layers of the
 living bone] were most strongly coloured.
 But he observed also, ~~that the interior~~ ^{of a young pig} ~~which had been fed a fortnight on madder~~
 in another ~~young pig~~ killed a fortnight after
 the madder had been omitted from its
 food, ~~(similarly fed, but~~

Strom states that "the exterior of the bone,
 was found of the natural colour, but the
 interior red." ⁽⁺⁾ The inference deduced ~~by~~
 was that a new layer of bone, ~~formed~~
 during the absence of madder from the
 circulating system, had been formed, uncoloured,
 on the exterior surface.

Mr. Gibson endeavoured to invalidate the
 conclusion by ^{suggesting} ~~supposing~~ that the
 coloring matter might have been
 removed from the previously stained
 bone by the serum of the blood, which fluid
 he believed to have a greater affinity
 for the dye than phosphate of lime
 had: but the experiments of Mr. Paget
 have proved that the phosphate
 have actually the stronger affinity
 for the dye.

The well-known fact that the phosphate
^{internal or external of the bone, which is}
 on every surface, exposed to the current
 of the dye-charged plasma, attract
 the dye, by no means invalidates the
 conclusions from the ingenious experiments
 of Hunter; for the quantity of colour is limited
 by

~~Trans. Soc. for Improvement of Med. & Phys. Knowledge~~
 vol. ii p. 278.

Gave a better physiological explanation
of them

But the chief value of Hunter's experiments and
observations was the better physiological
explanation which they gave of the phenomena.

Journal of 33. Dec. 11. The skeleton

the previously +
by completely formed bone is always
much less than that which the growing
bone receives from the phosphates deposited
during the presence of matter in the
circulating system.

Hunter's experiments, therefore, coincide
with those of Du Rornel made by
encompassing the shafts of growing
bones ^{with} rings of wire, in proving that
the increase in circumference is due
to growth at the periphery beneath
the periosteum: such rings having been found, after a certain
period of growth, in the cavity
The growth in length is however, ^{of the bone}
much more active; and this, in ^{enlarged}

The long bone of mammalia, takes
place ^{chiefly} almost exclusively at the
cartilaginous ends beneath the
epiphyses.

This is proved by boring holes, or
^{intracortical shots}
in the diaphyses of growing bones; and
examining the perforations after a week
or a fortnight after the experiments.

The intervals between the holes next the
ends of the bone are found much
increased whilst those ^{nearer} the middle uniform &
are but little if at all changed.

But the growth of a bone is not by general extension, but by accelerated
extension of parts is not the sole particular increase
process which takes place in the
growth of bone: & adapt the
bone to its specific office changes are
wrought in it by the absorption of parts
previously formed, is the especially
in the higher classes of animals

in the lower Vertebrata
in the lower Vertebrata

in

In some of the higher cartilaginous fishes, for example, an osseous crust is ^{formed} ~~deposited~~ upon the periphery of certain cartilages, in the form of prisms, which contain oval calciferous cells, but without conspicuous radiated tubes.

Among terrestrial Mammals the inactive Sloths and their great extinct congeners the Megatherium & Mylodon, ^(Ill. Pl. 83) have the long bones of the extremities solid; whilst the agile Ruminant shows each diaphysis in the condition of the ^{solid} hollow column; ~~both~~ both the strength and lightness of the bones being increased by the progressive absorption of the ~~gross~~ first-formed substance, as new bone is deposited from without. The condition of ~~the~~ which is illustrated by this section of the femur of the Nilghau, is common, in fact, to the long-bones of all ^{terrestrial} Mammalia except those above specified.

In Fishes, we observe, a simple unmodified increase, ^{specimens} ~~But in some~~ ossification, ^{commences at the periphery of the animal mould or basis: and} is always limited to a thin outer crust of the bone, the rest remaining cartilaginous ~~or gelatinous~~. Such bones in a dried or fossil state seen, to have had large internal or medullary cavities: ^{but they were filled by unmodified animal basis.} to whatever extent the bone of a fish is originally ossified, but ~~ossified parts~~ it remains, and consequently most of the bones of fishes are solid or spongy in their interior.

The bones of the Chelonians are, likewise solid: a coarse diploe fills the interior of the long-bones of the extremities; and we find a similar structure in the bones of the Cetacea & of the Seal-tube. ~~I and in the~~ ~~gigantic extinct~~ ~~other~~. ~~All other Mammals~~ ~~the Saurians, and most of the Batrachians~~ ~~likewise~~ ^{likewise} have ^{the cavity} ~~in~~ the each long bone, called 'medullary,' part it containing a cellular tissue, filled by a fine-light oily matter or 'marrow'. The ribs of the large Ophidians have, likewise, their medullary cavities. The bodies of the vertebrae of some lizards and the great extinct 'Pachypleuron' are ^{similarly} excavated. The medullary cavities of the ~~long bones~~ ^{of the extremities} of the ~~colossal~~ ^{colossal} ~~Spermocodon~~ ^{Spermocodon} & ~~Megalosaurus~~ ^{Megalosaurus} are ~~so developed~~ ^{so developed} as in any Mammalian Encephalon, and the white crystallized

In the ordinary marrow-bones of quadrupeds
 the walls of the cavity are thickest & strongest at
~~towards~~ the middle, and become thin
 towards the ends, where the peripheral concentric
 lamellae are separated by wider interspaces
 and are broken up into a fine lattice or
 lace-work. As the cavity and the cells
 are lined by a delicate membrane,
 less vascular than the external periosteum,
 which secretes & immediately contains
 the marrow: this fine oily fluid diminishes
 the brittleness of the ~~bones~~ ~~to their~~ bones.
~~elasticity~~ A special artery called the
 'medullary' ^{supplies} ~~supplies~~, in most mammalia: the
 lining membrane of the medullary cavity;
 and the foramen and canal have the same
 relative position and course in most
 mammalia as in Man; to wit, the canal
 in the humerus and tibia inclines distad; in
 the femur and anti-brachial bones proximal
 as it approaches the medullary cavity: the
 true Ruminants however, present an exception
 as regards the femur, in which the medullary
 artery instead of penetrating the back part of
 the shaft and running upward, enters the
 fore-part of the shaft at its upper third and
 inclines downwards. /

petrified bones

spas, which ^{with these fossils} are often filled
is called 'fossil marrow' by the
quarry-men. §

~~(Mammalia Artium)~~

The flat bones of Mammalia, e.g. those of the cranium,
~~the~~ the scapula and ~~the~~ ilia, have
a spongy texture, called diploë, included
between two compact plates; the internal
one in the cranial bones is called 'the vitreous
table' from its density & brittleness. But the
most compact example of the spongy tissue
is the petrous bone containing the organ of
hearing, thence called 'petrous', which,
with the tympanic bone, reaches the maximum
of density in the Cetacea.

The bones of Birds, especially those of flight,
present the opposite extreme of lightness:
not but that the spongy tissue itself is
more compact than in most Mammalia;
but its quantity in any given bone is
much less; the most admirable economy
being traceable throughout the
Skeleton of Birds in the advantageous
arrangement of the material for the
office it is destined to perform..

Thus in the long bones the cavities, analogous
to the medullary in Mammals, are
~~more~~ extensive and the solid walls of the bone
much thinner; a large aperture, called
the 'foramen pneumaticum', near one or
both ends of the bone, communicates with
its interior; and an air-cell, or prolongation
of the lung, is continued into and lines the
cavity, which is thus filled with rarefied
of the bone, air

air instead of marrow. The extremities of the bone, instead of being occupied by a ^{diploë} open network, spongy ~~structure~~, present a light ~~reticulated~~ ^{structure}; slender columns shooting across in different directions from wall to wall, and these columns are, likewise, hollow. The vastly expanded beak ^{of the booby and} with its horn-like process, in the Hornbill, forms one great air-cell; with thin bony parietes; and in this bird, ^{in the swifts & the humming birds,} every bone of the skeleton, down to the phalanges of the claws, is ~~also~~ pneumatic.

On the Mammalian class the air-cells of bone are confined to the head, and are filled from the nasal or tympanic cavities, never from the lungs.

The frontal, ^{sphenoidal & maxillary} sinuses, ~~and the mastoid cells~~ are examples of pneumatic bones in the human subject.

They ^{frontal sinuses} extend backwards over the calvarium in most Ruminants, and penetrate the cores of the horns in Oxen, Sheep & a few Antelopes.

On whole diploë of the upper, back and side walls ~~of~~ of the cranium was inflated, as it were, with air in the great extent to this: the outer table raised considerably above the vitreous.

The extent to which the skeleton is permeated by air varies in different Birds, in relation chiefly to their different kinds & powers of flight.

The opposite extreme to the swift ~~is met with in~~ the terrestrial apteryx & aquatic Penguin, in which not any bone of the skeleton receives air.

124
1000
The ^{outer} ~~upper~~ table of ^{the} antero spiraculum, with the ~~inner~~
is similarly raised above the inner
one by intervening large air-cells,
& thin ^{divinous} septa, in the Giraffe:
the short ~~simple~~ horns are solid, but
are sustained by the vaulted roof of the
skull; and as the animal can
dent heavy blows with these simple
weapons, the concussion is
diminished by the interposition
of these air-chambers between the
outer table & the immediate
covering of the brain. /

extremes, and the brain thus seemingly defended by a double skull; the advantage of which modification to in the point of bones from ^{the} falling trees, which these leaf-devouring animals, ^{they} is well displayed in the healed fractures of the skull of the *Myiodon* in the Museum of the College. (XII, p. 157).

The most remarkable development of air-cells in the Mammalian class is, however, presented by the Elephant; the ~~air~~ intellectual pyrrhism of this great Pachyderm, ~~arising from the great~~ Capacity of the brain-case, but being caused, as in the Owl, not by actual by the enormous extent of the pneumatic cellular diploe between the outer two tables of the Skull.

(Par)

In each of these modifications, the vacuities of the ~~specimen~~ ^{bones}, whether ^{more} cancelli as in the Isthmus, or small medullary cavities as in the Poroides, or larger medullary cavities as in Mammalia, or pneumatic cavities and sinuses, are the result of secondary changes by absorption & not of the primitive constitution of the bones. These ~~are~~ ^{are} in all air-breathing animals and the ~~can~~ vacuities are formed by the removal of opaque matter previously formed, whilst fresh bone is added to the exterior surface. The thinnest-walled & hollowest pneumatic bone of the bird of flight was first solid, ~~the~~ ^{most} a marrow-bone, and ~~finally~~ ^{finally} the case of an air-cell.

~~the~~ air-cell. The ~~solid~~ ^{bones} of the
Penguin & the medullary femur of
the Apteryx & Dimorphia ~~and the~~ ^{and the} pneumatic
wing-bone of the Eagle ~~had previously~~ ^{had previously} papers.
are arrested stages of that course of
development through which

In proceeding ~~on~~ after the foregoing
~~general~~ survey of the ^{general} nature, chemical
constitution, development, growth and
structure of the open system to the
~~and~~ description of the skeleton ~~and~~
~~its component parts~~ in the Vertebrate
Animals, I feel myself first called
upon to define a bone, and the
endeavour to do this

has not been the least difficult
part of my task, - with reference to
the applicability of the definition
to the Vertebrate Series in general.

to the

~~very properly describes it as composed of
the proper bones of the cranium consolidated,
as it were, into a single piece.~~

To the Human Anatomist the question - what is a bone? - may appear a very simple, if not a needless, one: he will most probably reply that a bone is any single piece of osseous matter entering into the composition of the adult skeleton, and agreeably with this definition he will enumerate about 260 bones in the Human skeleton.

See

Jaenmering, who includes the 32 teeth in his enumeration, reckons from 259 to 264 bones: but he counts the os sphenoccipitale as a single bone, and also regards, with ~~the~~ previous Anthropotomists, the 'os temporis' the 'os sacrum' & the os innominatum ~~as single~~ ^{individual} bones: the sternum, he says, may include 2 or 3 bones: &c. (XIII, p. 6).

But, in Birds, the os occipitale is not only ankylosed to the sphenoid, but ~~all the cranial bones early coalesce together~~ these early coalesce with the parietals & frontals, and, in short, the entire cranium proper consists, according to the above definition of a single bone: Blumenbach, however, applying the human Standard, describes it as composed of the proper bones of the cranium consolidated, as it were, into a single piece. (XIV, p. 56.) And, in the same spirit most modern Anthropotomists, influenced by the comparatively late period at which the sphenoid becomes ankylosed to the occipital in Man, regard them as two essentially distinct bones. In directing our survey downward in the Mammalian scale

we

and just as the human cranial bones
 lose their individuality in the Bird, so
 do those of the Marsupial lose their
 individuality, in the ordinary Mammalian
 or Human Skull. In many Mammalia
 we find the pterygoid process of another process
 permanently distinct bones: even in Birds
 where the process of apicic confluence is so
 general and rapid, the pterygoids and tympanics
 which are subordinate pieces in the
 Man, are always independent bones. /

~~Most authors for instance, influenced by the comparatively late period at which the basic phenomenon became employed to the occipital, regard I describe them as two essentially distinct bones. And when we begin to apply this definition, of the human anatomy, I have not found, in the lower animals, we~~

we speedily meet with examples of persistent divisions of bones which are single in Man. Thus it is rare to find the basi-occipital confluent with the basi-sphenoid in ^{mammalian} quadrupeds, and before we quit that ~~class~~ class we meet with adults, as in some of the mammalian & monotrematous species, for example, in which the supra-occipital,

"pars occipitalis propriae sic dicta," ~~is~~ ^{of Solen.} ~~is~~ distinct from the condyloid parts and thus from the basilar or coniform process of the os occipitis:

in short the single ^{occipital} bone in Man is four bones in the *Aspion* or *Schizura*: I

~~in the osseous animal, and in other mammalia we find the pterygoid processes of the sphenoid of another part, distinct bone.~~

In many *Mammalia* the styloid, and the auditory, ^{the petrous,} and the mastoid processes remain distinct from the ^{squamous or} main part of the temporal, throughout life, and ~~some~~ some of them claim the name to be regarded as distinct bones, since they obviously belong to ^{different, natural} ~~different~~ groups of bones in the skeleton; as the styloid process, for example, to the series of bones forming the hyoidium

and ~~the~~ ^{the} artificial character of that view of the ~~the os occipitis~~ ^{the os occipitis}, in which this obviously consists in ~~mammalia~~ ^{mammalia} of more or less confluent series of modified vertebrae,

The Swift or the Hawk

excitements to obtain food for two callow brood
when hatched; with ^{demonstrating} bold defense which
the (at other times timid, & c.) will make
against ~~any~~ ^{the} threatened danger to
her young. Still closer becomes

The link between the parent & offspring as we
~~it~~ ^{is} ~~more~~ ^{is} ~~still~~ ^{is} ~~closer~~ ^{is} ~~in~~ ^{is} ~~the~~ ^{is} ~~highest~~ ^{is} ~~Vertebrate~~ ^{is}
~~Subkingdom~~ ^{by the} ~~substitution~~ ^{substitution} for the exclusion of a
~~offspring~~ ^{first} ~~and~~ ^{of the} ~~the~~ ^{birth} ~~of~~ ^{living}

unresponsive organism, ^{of the} ~~of~~ ^{birth} ~~of~~ ^{living}
offspring, deriving its nutriment immediately
from the Parents' body, ^{both} giving and receiving
pleasure by that act.

To this is finally added, in man,
the prolonged dependence of a
slowly maturing offspring on
the ~~care~~ ^{care} ~~and~~ ^{and} ~~affection~~ ^{affection} ~~in~~ ⁱⁿ ~~which~~ ^{which} ~~are~~ ^{are} ~~the~~ ^{the}
care, and affection; ⁱⁿ ~~the~~ ^{the}
foundation of ^{the} ~~social~~ ^{social} ~~relations~~ ^{relations} ~~of~~ ^{of} ~~life~~ ^{life}
and the preparation for the reception
of those ~~higher~~ ^{higher} ~~principles~~ ^{principles} ~~by~~ ^{by} ~~which~~ ^{which}
the ~~man~~ ^{man} ~~is~~ ^{is} ~~born~~ ^{born} ~~into~~ ^{into} ~~the~~ ^{the} ~~world~~ ^{world} ~~of~~ ^{of} ~~existence~~ ^{existence}

I trust happiness are based; and by
for which he is fitted for another and a higher
sphere of existence.

making irresistible appeal,
with its true voice, ~~as~~ ^{as} ~~the~~ ^{the}
from ~~the~~ ^{from} ~~the~~ ^{the} ~~care~~ ^{care} ~~of~~ ^{of} ~~the~~ ^{the} ~~parent~~ ^{parent} ~~care~~ ^{care}

is counted as ^{component} ~~forming the osseous~~ as a single ~~component~~ ^{forming the skeleton}, is sufficiently obvious.

The os innominatum is represented throughout ^{in most Reptiles} life by ^{three} distinct bones, answering to the iliac, ischial & pubic portions in another position.

The Sternum in most quadrupeds consists of one more bone than the ^{number of} pairs of ribs which join it; ^{thus it includes} ~~as~~ ^{as} ~~many~~ as 13 distinct bones, ~~for example~~, in the Bradypus didactylus. ~~Even in the Bird's beak, which~~

The arbitrary character of the definition of a bone, above cited ^{and} the ^{essential} ~~true~~ nature of many of the single bones and processes of bone in another position, ~~many~~ are taught by ~~the learned~~ ^{anatomists} ~~for~~ anatomy properly so called, which ~~reveals~~ ^{reveals} the true natural groups of bones, and the modifications of these which peculiarly characterize the Human Subject.

It will occur to those Anatomists who have studied Human Osteology, ~~and~~ that those parts of the ~~bone~~ single bones of another position which have been adduced as constituting permanently distinct in lower animals, are originally distinct in the Human fetus. The occipital bone, for example, is a piece from four separate centres: the pterygoid process have distinct centres of ossification: the styloid & the mastoid process, and the tympanic ring are separate parts in the fetus. The constituent vertebrae of the

Cervix

scrum remain longer distinct: and ~~still later~~ the ilium ischium and pubes are still later in uniting together to form the 'nameless bone'. ~~and the like~~

These ^{and the like} correspondences between the points of ossification of the human foetal skeleton, and the separate bones of the adult skeletons of inferior animals, are pregnant with interest, and rank among the most striking ~~phenomena~~ ^{illustrations} of the ~~plan~~ ^{plan} of Ontogeny of Organization in the Vertebrate Series.

Cuvier, ~~after~~ commenting on the arbitrary ~~and~~ character of some of the definitions of single bones of the Anthropomorphia, goes so far as to state that in order to ascertain the true number of bones in each species, we must ascend to the primitive osseous centres as they are manifested in the fetus.†

† According to this rule we ~~must~~ ^{ought to} count the humerus as three bones, and the femur as four bones instead of one: for the ossification of the latter begins at four distinct points, one for the shaft, one for the

† "Mais ces distinctions sont arbitraires, et pour avoir le véritable nombre des os de chaque espèce, il faut remonter jusqu'aux premiers noyaux osseux tels qu'ils se montrent dans le fœtus." (XIII, tom. ~~LXXXV~~ i, p. 120.)

the head, one for the great trochanter
and one for the distal condyles. ~~By which~~
~~will surely these parts and processes~~
~~will be regarded as distinct bones!~~
~~There is no such distinction~~ is
~~is~~ kept up in any of the lower
classes. In both Birds and Reptiles
the femur is developed from a
single centre.

The rule laid down by the great French Anatomist
fails in its application to the difficult point
under consideration because he did
not distinguish between those centres
of ossification that have homological relations
and those that have only teleological ones:
i.e. between the separate points of ossification
of a human bone which typify permanently distinct
bones in the lower animals, and the separate
points which, without such signification, facilitate
ossification and ~~relate to the~~ have for their final
cause the well-being of the growing animal.

~~homological relations~~
~~those that have~~ teleological
ones.

(Lamb or foal)
The young ~~animal~~, for example,
~~as soon as it is born, it~~ comes down on its
four legs, lifts its body well above
the ground, and quickly begins to run &
bound. ~~the shock to the limbs~~
themselves is broken & diminished at this
tender age, by the divisions of the
supporting

34 a

is further diffused and intercepted by the
epiphysial articular extremities of the
bodies of the vertebrae

Mammalian vertebrae show a tendency
complex: epi-physial ends of body for
a purpose - separate neuroapophyses
in conformity with pal canal

When the Reptile moves by leaps, then the principle
of ossifying the long bone ^{by distinct centres} again prevails, and
the extremities of the humeri and femora
long remain epiphyses in the wing. /

Supporting long bones, - by the
interposition of the cushions of
cartilage between the diaphyses
of the epiphyses. And in ~~the~~ ^{that might affect}
some degree the ~~the~~ ^{the} pulpy &
largely developed ~~bram~~ ^{of the immature mammal}
~~the same degree~~ ^{of the immature mammal}

We ~~may~~ ^{thus} readily discern a final
purpose in the distinct centres of ossification
of the long bones of ~~and~~
the limbs of Mammals, which
would not apply to ~~the~~ ^{the condition of the}
crawling Reptiles, etc.

The diminutive vesicle in these low &
slow cold-blooded animals does
not demand such protection against
compression: neither does the mode
of locomotion in the quadruped
reptiles render such compression likely;
their limbs are spread outwards,
and push along the body, which
commonly trails ^{upon} the ground:
therefore we find no epiphyses
with interposed cartilage at the
ends of a distinct shaft in the long bones in
~~the class~~ of Saurians and Testudoines. But when

A final purpose is no doubt observed
in most of the separate centres of ossification
which ~~have~~ ^{relate} to permanently
homologically

distinct bones in the general Vertebrate series;
it has long been recognized in relation to the facilitating birth
in the human fetus:
but some facts will occur to the Human
Osteogenist, of which ~~no~~ ^{no} teleological
explanation

channels opened to scapula on
outside -

21

[illegible]

can be given.

One sees not, for example, why the process of the scapula, which gives attachment to the pectoralis minor the coraco-brachialis & the short head of the biceps, should not be developed by continuous ossification from the body of the blade-bone, like that which forms the spinous process ~~of the same bone~~ of the same bone.

~~The~~ It is a ^{well-known} fact, however, that not only in Man but in all Mammalia the coracoid process is ossified from a separate centre. In the Monotremes it is ~~not only~~ ^{not only} a distinct, ~~and as~~ ^{but is} large bone, as ~~it is~~ in Birds, ~~the~~ Reptiles, & ~~this~~.

Here, then, we have the homological, without a ~~hint of the~~ teleological explanation of this ~~fact~~ distinct centre in the ossification of this ^{distinct} centre in the ^{development} of the ^{bone}. This distinction ^{is indispensable} in the nature and relations of such centres, ~~in the~~ ^{in the} application of the facts of osteogeny to the determination of the number of essentially distinct bones in any given skeleton, has never been considered ^{so far as I know} in that ~~point of view~~ application.

(Anatomical)
of the
Human
blade-bone.

Some Monotremes have gone beyond ^{even} ~~the~~ ^{still} ~~more~~ beyond nature, in ^{arguing} ~~affirming~~ ~~that~~ the number of individual bones, as indicated, by the number of separate centres of ossification in the embryos, ^{to be} ~~is~~ the same in ~~every~~ ^{all} Vertebrate animals; and that they ~~seemed~~ afterwards

The first addition is to original 89
of hand & dry parts of the
the breadth of continuing about four

*agony
of the hour of death
but, finding this
weak & faint
the present
of the Kingdom
which also
affords us
opportunity &
comfort,
from whom
are so many
portents
in the Gospel
John A K.
Benedictine
in the time*

or seemed to differ,

I differed only by reason of the greater or less rapidity or extent of the confluence of those apicific centres or essentially distinct bones of separate opens pieces, in the vertebrate series. ^{primitive conformity} This I will ^{however} not, only in regard to the separate centres of ossification of those bones of higher animals which have to the permanently distinct bones of lower species, homological relations, it by no means applies to those which have merely teleological ~~and~~ relations.

Henry [But, besides the epiphyses of the long bones of mammalia, which enter into the latter category, and cannot ^{therefore} be properly viewed ^{in the light of} as distinct bones; what are we to say to the intercalated, inconstant, 'open Wormian', or to the apicified tendons of birds, or to those developed in the tendons of the vertebral muscles of the Musk-deer! Are these to be reckoned ~~as~~ equally distinct and individual bones of the skeleton ^{with} the occipital & parietal bones, with ^{the dorsal} the vertebrae or the tibia? In

~~of a truth it is by no means an easy matter to determine what shall be considered as a distinct and individual bone in the vertebrate series generally. and yet we must come to some understanding on this point before we begin to trace the ordinary homology of individual bones. I believe that, in descriptive anatomy, some a bone must be defined, arbitrarily, in each species, as ~~that~~ ^{opens} any single piece which enters into of which the skeleton of the mature animal is composed.~~

Bones

In Man -

All the long or cylindrical bones

are histologically compound; almost all

~~the~~ the flat bones and many of the thick or mixed bones

(Vertebrae & Sternum) ^{sacrum} histologically compound.

are

In considering this & other questions previously
discussed you will begin to ^{appreciate} ~~perceive~~ the
difficulties in defining, or determining
what shall be considered a distinct and an
individual bone in the skeleton

If we apply to each species the arbitrary
definition of a bone ^{in Anthropotomy,} ~~as~~ "any single
osseous piece of which the skeleton of
the mature animal is composed," we
must qualify it by subordinate definitions of
~~the~~ the different natures of ~~these~~ separate
pieces: ^{of the skeleton,} ~~these~~ ^{bones} have been primarily
classified, according to their form, as long and
cylindrical; broad & flat, thick and squarish,
symmetrical & asymmetrical. (XII, ⁱⁱ p. p. 9, 10)
or according to their position, into median & lateral (XV, p. ^{xviii}),
~~according to the~~ ^{into} endo-skeletal, exo-skeletal
and oplanchno-skeletal (I, p. 113, 115.) But besides
these, ^{the above described} ~~the~~ deeper and more essential differences
of the bones require that they should also be
divided into simple

* These are mostly symmetrical; but the youngest anthropotomist
must have met with instances of a curved vomer, and an
asymmetrical ^{sym} ~~sternal~~ ^{bone} on the other hand most of
the phalanges among the ^{paria, see} ~~opa~~ ^{lateralia} are asymmetrical.

the general, serial and special homologies of each bone throughout the Vertebrate Series.

By general homology I mean the relation in which one bone stands to the primary segment of the skeleton of which it is a part; thus, when the basi-occipital bone ('basilar process of the occipital' in Anthropotomy) is said to be the 'centrum or body of the occipital or posterior cranial vertebra', its general homology is enunciated. When it is said to repeat in its vertebra, or to answer to, ~~the body of the atlas~~ vertebra, ~~as the basi-sphenoid in the parietal vertebra~~, its serial homology is indicated: when the essential correspondence of the basilar process of the occipital bone in Man with the distinct bone called 'basi-occipital' in a quadruped or fish is shown, its special homology is determined. //

or the body or centrum in the atlas, dentata or any other of the ~~anatomical~~ vertebral segments of the skeleton