AN INTRODUCTION

TO THE

OSTEOLOGY OF THE MAMMALIA

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WITH NUMEROUS ILLUSTRATIONS.

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exit to the inferior division of the first cervical nerve, but not by the vertebral artery, which usually enters the neural canal between the arches of the second and third vertebræ. The odontoid process of the axis (Fig. 14) is of peculiar shape,

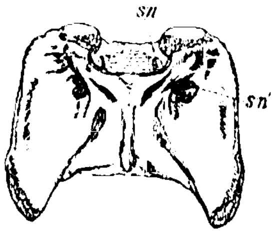

FIG. 13.—Inferior surface of atlas of Red Deer (*Cervus elaphus*). *sn* foramen for first spinal nerve; *sn′* foramen for inferior branch of the same nerve.

being like a spout, or hollow half-cylinder, with a prominent sharp semicircular rim. The canal for the second cervical

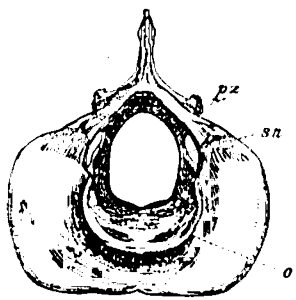

FIG. 14.—Anterior surface of axis of Red Deer. [illegible]. *o* odontoid process; *sn* foramen for second spinal nerve; *pz* posterior zygapophysis.

spinal nerve pierces the lamina of the axis near its anterior border. The other vertebræ have more or less elongated bodies, which are *opisthocœlous*, i.e. concave behind and convex in front. They are keeled below, the keel being often

developed into a hypapophysial spine posteriorly; the neural spines are moderately long, and inclined forwards. The transverse processes of the fifth, and especially of the sixth have large inferior lamellæ. That of the seventh is usually imperforate.

In the Giraffe the bodies of the cervical vertebræ are very long. The transverse processes are short, but so extended from before backwards as to become divided into two, one at the anterior and one at the posterior end of the vertebra. That of the seventh is perforated.

In the *Tylopoda* (Camels and Llamas) the vertebrarterial canal passes obliquely through the anterior part of the pedicle of the arch, being in its posterior half confluent with the neural canal. A similar condition occurs in *Macrauchenia*, an extinct South American Perissodactyle Ungulate.

The *Suina* and *Tragulina* differ from the remaining existing Artiodactyles in the form of the odontoid process, which is conical; while on the other hand the Horse and Tapir among the Perissodactyles have this process wide, flat, and hollowed above, approaching the form it presents in the Ruminants. In the Pig, the broad pedicles of all the cervical vertebræ are perforated by canals for the passage of the upper division of the spinal nerves.

The bodies of the cervical vertebræ in the Rhinoceros, Tapir, and Horse are markedly opisthocœlous, but in the Pig and Hippopotamus very slightly so.

In the Horse the bodies of the cervical vertebræ are elongated, with a strong keel and hypapophysial spines. The neural laminæ are very broad, the spines almost obsolete, except in the seventh, and the transverse processes not largely developed. The seventh is not perforated by the vertebrarterial canal.

In the Rhinoceros, on the other hand, the bodies are varies much in the different genera, from 18 (13 thoracic and 5 lumbar) in *Tupaia*, 19 (13 and 6) in *Talpa* and most *Soricidæ*, 19 (14 and 5) in *Galeopithecus*, 21 (15 and 6) in *Erinaceus*, 22 (19 and 3) in *Chrysochloris*, to 24 (19 and 5) in *Centetes*.

There are also great differences in the development of the processes of the vertebræ, which appear to accord with the diversities in the habits and movements of the animal. The transverse processes of the lumber vertebræ are very short in the comparatively slow-moving, running, or burrowing Hedgehogs (*Erinaceus*), Shrews (*Sorex*) and Moles (*Talpa*), but they are very long, broad, and inclined downwards in the jumping *Macroscelides* and *Rhynchocyon*, where the lumbar muscles are greatly developed and the hinder extremities disproportionately large.

In the Mole, there are distinct, small, oval, flat ossicles on the under-surfaces of the interspaces between the lumbar vertebræ. Similar ossicles, but in a more rudimentary condition, are occasionally found in the same situation in some other Insectivora, as the Hedgehog, but not in any other Mammals.

The usual number of thoracic and lumbar vertebræ in the CHIROPTERA is 17 or 18, of which from 11 to 14 may bear movable ribs. The transverse processes of the lumbar vertebræ are almost obsolete, as are also the spinous processes throughout the series.

Among the RODENTIA, the most prevalent number is 19; but it rises as high as 23 (16 and 7) in *Capromys*, and even as 25 (17 and 8) in *Loncheres*.

The characters of the vertebræ vary much in the different genera, as among the Insectivora. In the Hares (genus *Lepus*) the anterior thoracic vertebræ have long slender spinous processes; the lumbar vertebræ (see Fig. 3, p. 18) have very long and slender transverse processes directed downwards and forwards and widening at their extremities; long metapophyses projecting upwards and forwards, small anapophyses, and remarkably long, single, compressed median hypapophyses. These latter are not found in the Rodentia generally.

In the UNGULATA, the bodies of the trunk vertebræ are generally slightly opisthocœlous. The spinous processes in the anterior thoracic region are exceedingly high and compressed. The transverse processes of the lumbar vertebræ are long, flattened, and project horizontally outwards or slightly forwards from the arch. The metapophyses are moderately developed, and there are no anapophyses. The canals for the exit of the spinal nerves frequently pierce the pedicle of the neural arch (as in the Eland and Cape Buffalo).

In the Artiodactyle sub-order the number of thoracic and lumbar vertebræ together is almost always 19, though the former may vary from 12 to 15. Among the Perissodactyles the number 23 is equally constant, the Horse and Tapir having 18, and the Rhinoceros 19 thoracic vertebræ.

Some species of Hyrax (*H. capensis*) have as many as 22 thoracic and 8 lumbar vertebræ, making altogether 30, the highest number in any terrestrial Mammal; whilst in Dendrohyrax the numbers are 21 and 7.

The Elephants have 23 in all, 19 or 20 of which bear ribs.

In the order SIRENIA, the thoracic vertebræ are numerous and the lumbar very few; thus the Dugong (*Halicore*) has 19 thoracic and 4 lumbar, and the Manatee (*Manatus*) 17 and 2. The bodies are rather triangular, being compressed and keeled below, and in the young state have no distinctly ossified terminal epiphyses. The bodies of all the thoracic vertebræ bear articular facets for the heads of the ribs. The spinous processes are not very high, but the

Pinnipedia.	Cervic.	Thorac.	Lumb.	Sacral.	Caudal.
Otaria stelleri	7	15	5	4	14
* ,,	7	16 left side 15 rightside	4 5	5	12
californiana	7	15	5	3	10
australis	7	15	5	4	10
ursina	7	15	5	3	11
Trichechus rosmarus	7	14	6	4	8+
* ,,	7	14	6	4	12
Halichœrus grypus	7	15	5	4	14
Phoca vitulina	7	15	5	4	12
hispida	7	15	5	3	15
,,	7	15	5	4	13
grœnlandica	7	15	5	4	15
Stenorhynchus leptonyx	7	14	6	3	14
carcinophagus	7	15	5	3	12
Cystophora cristata	7	15	5	3	14
Macrorhinus leoninus	7	15	5	3	11
UNGULATA.					
Bos taurus	7	13	6	5	19
*Bos primigenius	7	13	6	5	—
*Bubalus depressicornis	7	13	7	4	18
* caffer	7	13	6	4	18
Bison americanus	7	14	5	5	13+
* ,,	7	14	5	5	15
bonasus	7	14	5	4	17
*Ovibos moschatus	7	13	5	6	—
Ovis aries	7	13	7	4	7+
musimon	7	13	6	4	—
nahoor	7	13	6	4	10
tragelaphus	7	13	6	4	14
Capra ibex	7	13	6	4	9
hircus	7	13	6	4	13
Boselaphus tragocamelus	7	13	6	5	—
Gazella dorcas	7	13	6	4	14
Saiga tartarica	7	13	6	4	10
Tetraceros quadricornis	7	13	6	4	8+
Connochætes gnu	7	14	6	4	14+
*Antilocapra americana	7	13	6	4	—

Ungulata.	Cervic.	Thorac.	Lumb.	Sacral.	Caudal.
Giraffa camelopardalis	7	14	5	4	12
* ,,	7	14	5	3	20
Moschus moschiferus	7	14	5	5	6
,,	7	13	6	5	7
Cervulus muntjac	7	13	6	4	—
Cervus davidianus	7	13	6	4	14+
* canadensis	7	13	6	4	13
elephus	7	13	6	4	11
dama	7	13	6	4	—
hibernicus	7	13	6	5	—
Rangifer tarandus	7	14	5	5	11
,,	7	14	5	4	11
Alces machlis	7	13	6	4	10+
Capreolus caprea	7	13	6	6	8
Hydropotes inermis	7	12	6	4	10
Cariacus mexicanus	7	13	6	4	13
Pudua humilis	7	13	6	5	8
Tragulus javanicus	7	13	6	5	13
Camelus bactrianus	7	12	7	4	15+
* dromedarius	7	12	7	4	13+
Auchenia glama	7	12	7	5	13+
* ,,	7	12	7	4	9+
pacos	7	12	7	5	13
vicugna	7	12	7	4	14
Dicotyles tajacu	7	14	6	4	7
,,	7	14	5	4	7
,,	7	14	5	5	—
Sus cristatus	7	13	6	4	24
scrofa	7	14	5	4	21
,,	7	14	6	4	24
Babirussa alfurus	7	13	6	4	—
Phacochœrus africanus	7	13	5	2	23
Hippopotamus amphibius	7	15	4	6	11+
,,	7	15	4	8	13
Tapirus indicus	7	18	5	6	—
americanus	7	18	5	6	12
Equus caballus	7	18	5	6	15+
,,	7	18	6	6	—
,,	7	19	6	5	—
,,	7	19	5	5	—
asinus	7	18	5	5	—
zebra	7	18	6	5	17
Rhinoceros unicornis	7	19	3	6	21+
sumatrensis	7	19	3	4	22

Ungulata.	Cervic.	Thorac.	Lumb.	Sacral.	Caudal.
Rhinoceros sumatrensis	7	20	3	4	—
Hyrax capensis	7	22	8	7	4
Dendrohyrax arboreus	7	21	7	6	7+
dorsalis	7	21	7	6	8
Elephas indicus	7	20	3	4	30+
,,	7	19	5	4	—
,,	7	19	4	4	24
africanus	7	19	4	5	24+

Sirenia.	Cervic.	Thorac.	Lumb.	Sacral.	Caudal.
Halicore dugong	7	19	4		27
,,	7	18	4		20+
,,	7	19	5		27
Manatus americanus	6	17	2		23
senegalensis	6	17	2		25

Cetacea.	Cervic.	Thorac.	Lumb.	Sacral.	Caudal.
Balæna mysticetus	7	12	14		22
australis	7	15	10		25
Balænoptera rostrata	7	11	12		19
Physeter macrocephalus	7	11	8		24
Hyperoodon rostratus	7	9	10		19
Mesoplodon grayi	7	10	12		19
Berardius arnuxi	7	10	12		19
Platanista gangetica	7	10	9		26
Monodon monoceros	7	11	6		26
,,	7	12	7		24
Delphinapterus leucas	7	11	9		22
Phocæna communis	7	13	14		32
,,	7	12	14		30
Orca gladiator	7	11	10		23+
Pseudorca crassidens	7	10	9		23
,,	7	10	11		21
Globicephalus melas	7	11	13		28
Tursiops tursio	7	13	16		27
,,	7	12	17		—
Sotalia sinensis	7	12	9		23

Cetacea.	Cervic.	Thorac.	Lumb.	Sacral.	Caudal.
Lagenorhynchus acutus	7	15	20		35+
albirostris	7	14		67	
Delphinus delphis	7	15	21		32
,,	7	14	21		32
,,	7	14	20		34

Rodentia.	Cervic.	Thorac.	Lumb.	Sacral.	Caudal.
Sciuropterus volucella	7	12	7	3	16+
Sciurus vulgaris	7	12	7	3	21
indicus	7	13	6	3	24
,,	7	12	7	3	25
Tamias asiaticus	7	12	7	3	20
Spermophilus mongolicus	7	12	7	3	17
Cynomys ludovicianus	7	13	7	4	16
Arctomys marmotta	7	12	7	3	24
Castor canadensis	7	14	5	4	24
Muscardinus avellanarius	7	13	6	3	22
Hydromys chrysogaster	7	14	7	4	30
Cricetus frumentarius	7	13	6	3	17
Mus rattus	7	13	6	4	32
decumanus	7	13	6	4	27
fuscipes	7	13	6	4	26
musculus	7	13	5	4	—
,,	7	13	6	4	20+
minutus	7	13	6	4	30
Hapalotis albipes	7	14	6	4	20+
Fiber zibethicus	7	13	6	4	25+
Avicola amphibius	7	13	6	4	20+
agrestis	7	13	6	4	—
Myodes lemmus	7	13	6	4	10+
Ellobius talpinus	7	13	6	4	10
Spalax typhlus	7	13	6	4	6
Rhizomys pruinosus	7	15	5	5	18
Bathyergus maritimus	7	14	6	4	14
Georychus capensis	7	12	5	4	5+
Geomys bursarius	7	12	7	5	17
Zapus hudsonicus	7	13	6	4	35
Dipus sagitta	7	12	7	4	23
Alactaga jaculus	7	13	6	4	31
Pedetes caffer	7	12	7	3	30

The presternum is extremely compressed and projects forward like the prow of a boat. In the Tapir, its anterior portion is originally, and commonly remains, a distinct ossification (*pro-osteon*, Parker). The segments which follow gradually widen, and the hinder part of the sternum is broad and flat. The last mesosternal segment in the Tapir is generally divided in the middle line.

The sternum of the Rhinoceros is very narrow throughout, with a long, rather spatulate xiphisternum.

Order CETACEA.—Each of the two primary divisions of this order has a distinct form of sternum.

Among the *Odontoceti*, the typical Dolphins have a very broad presternum of peculiar form, emarginate in the middle line in front, and with a pair of lateral processes behind the attachment of the first pair of ribs. This is followed by two or three mesosternal segments but no xiphisternum. An indication of the primordial median fissure can generally be traced, except in very old animals, either as a hole in the presternum, or as a division of the posterior mesosternal segment.

In the Porpoise (*Phocæna*) the sternum is shorter and broader than in most Dolphins, and its various elements early coalesce into a single bone.

In the Cachalot (*Physeter macrocephalus*) the sternum ossifies from three distinct pairs of nuclei, and a large median fontanelle remains between the first and second pair.[1] In the specimen in the Museum of the Royal College of Surgeons (Fig. 37), which is very nearly adult, each half of the presternum (*ps*) has coalesced with the corresponding half of the first segment of the mesosternum (ms^1), but the resulting pieces are not united by bone across the middle line, while the second or last pair of mesosternal segments

[1] I have observed this in animals evidently of great age.

(ms^2) are ankylosed together mesially, but not with the portion of the sternum in front of them.

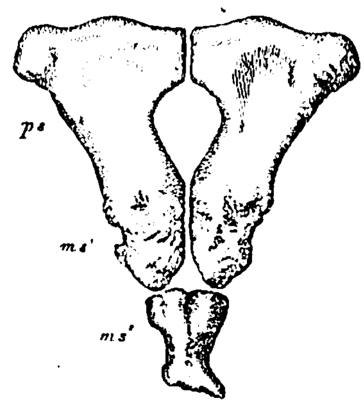

FIG. 37.—Sternum of Cachalot or Sperm Whale (*Physeter macrocephalus*), $\frac{1}{13}$.

In the Whalebone Whales (*Mystacoceti*) the sternum is comparatively rudimentary, consisting only of a broad,

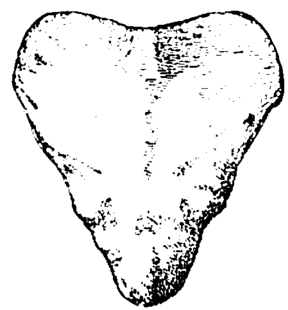

FIG. 38.—Sternum of Greenland Right Whale (*Balæna mysticetus*), $\frac{1}{12}$.

flattened presternum, produced posteriorly into a xiphoid process in some species. There are never any mesosternal

The portion of the rib between the head and the tubercle is called the *neck*; it is wanting in the last two ribs, in which the two attachments are blended. The greatest point of curvature on the external surface of the rib is called the *angle*.

Each vertebral rib has a main centre of ossification and two epiphyses, one for the head and (except in the last two) one for the tubercle.

The sternal ribs generally remain cartilaginous throughout life, being only partially ossified by endostosis in old age or under abnormal conditions. They are not distinctly separated from the vertebral ribs except by their difference of structure; but synovial joints are (except in the first) interposed between their inferior extremities and the sternum.

Among the higher *Simiina* the ribs do not differ very notably from those of Man, except in number; but in the lower forms, and especially in the *Lemurina*, they more resemble those of the Carnivora. Among the Old World Monkeys the number varies from 11 to 13 pairs. The Gorilla, Chimpanzee (*Troglodytes*) and Gibbon (*Hylobates*) have 13, and the Orang (*Simia*) 12. In the American Monkeys there are from 12 to 15 pairs; in the Lemurs from 12 to 17 pairs.

In the most typical forms of CARNIVORA the vertebral ribs are comparatively slender, subcylindrical, and little curved. The most anterior especially are short and straight, the thorax being thus more compressed in front than it is in Man and the higher Primates. The sternal ribs (see Fig. 33, p. 94) are long, slender, have a feeble granular ossification, and are not otherwise segmented off from the vertebral ribs. In all the *Felidæ* and *Canidæ* there are 13 pairs, in the *Viverridæ* 13 or 14, in the *Hyænidæ* 14 or 15, in the *Mustelidæ* 14 to 16, in the *Procyonidæ* 14, in the *Ursidæ* 14 or 15, in the *Pinnipedia* 14 or 15.

In the UNGULATA the ribs are generally more or less flattened and broad, notably so in the Ox and Camel, and least so in the *Perissodactyla*. The anterior ribs have scarcely any curve, the thorax being very narrow in this region. The sternal ribs (see Fig. 35, p. 97), especially those near the front of the series, are short, stout, rather flattened or prismatic, tolerably well ossified, and articulated with the vertebral ribs by a cup-and-ball synovial joint. The Artiodactyles have from 12 to 15 pairs of ribs, the Horse and Tapir 18, the Rhinoceros 19, the Elephant 19 or 20, and the Hyrax 20 to 22.

In the SIRENIA the total number of ribs is very great, though but few are attached to the sternum. In the Manatee they acquire an extraordinary thickness and solidity of texture. This animal has 17 pairs, of which but three are attached by flexible cartilages to the sternum.

Order CETACEA.—In the Whalebone Whales the ribs differ greatly from those of the rest of the Mammalia in their extremely loose connection, both with the vertebral column above and with the sternum below, probably to allow of greater alteration in the capacity of the thorax in respiration necessitated by the prolonged immersion beneath the surface of the water which these animals undergo.

At their vertebral extremities they are attached only by their tubercle to near the end of the transverse process, but apparently not by synovial articulation. The heads of only a few of the anterior ribs are developed, and are rarely sufficiently long to reach the bodies of the vertebræ, their place being supplied by a ligamentous band. The first rib is the only one connected with the sternum, either directly or indirectly, the whole of the remainder being free or floating ribs. The sternal ribs are mere cartilaginous rudiments, connected by an intermediate layer of fibrous tissue

Behind this the exoccipital gives off a very long paroccipital process (*pp*).

The periotic and tympanic are ankylosed together, but not with the squamosal. The former has a wide but shallow floccular fossa on its inner side, and sends backwards a considerable "pars mastoidea" which appears on the outer surface of the skull (*Per*) between the post-tympanic process of the squamosal and the exoccipital. The tympanic (*Ty*) forms a tubular meatus, directed outwards and slightly backwards. It is not dilated into a distinct bulla, but ends in front in a pointed styliform process which forms part of the outer wall of the Eustachian canal. It completely embraces the truncated cylindrical tympanohyal (*th*), which is of great size, corresponding to the large development of the whole anterior arch of the hyoid.

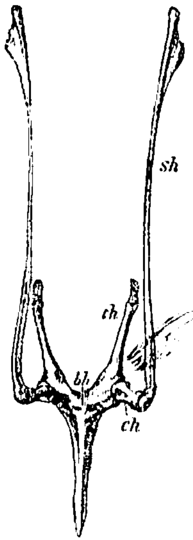

FIG. 61.—Superior surface of hyoid bones of horse. ¼. *sh* stylohyal; *ch* ceratohyal; *bh* basihyal; *th* thyrohyal.

The stylohyal (Fig. 61, *sh*) is of great size, compressed, and expanded at the upper end, where it sends off a triangular posterior process. Below the stylohyal, and usually becoming ankylosed with it, is a small nodular bone (epihyal), and then the arch is completed by a short cylindriform ceratohyal (*ch*). The basihyal (*bh*) is rather flattened from above downwards, arched with the concavity behind, and sends forwards a long, median, pointed, compressed "glossohyal" process. The thyrohyals (*th*) are compressed bars projecting backwards from, and in adult animals

completely ankylosed to, the lateral extremities of the basihyal.

Each ramus of the mandible has a long, straight, compressed horizontal portion, gradually narrowing towards the symphysis, where it expands laterally to form with the ankylosed opposite ramus the wide semicircular, shallow, alveolar border for the incisor teeth. The region of the angle is expanded and compressed, with a thickened rounded border without any process. The condyle is greatly elevated above the alveolar border; its articular surface is very wide transversely, and narrow and convex from before backwards. The coronoid process is slender, straight, and inclined backwards.

The skull of the Rhinoceros resembles that of the Horse in many essential features, but the occipital region is of much greater extent vertically, the form of the cranial cavity being concealed externally by large occipito-parietal air-cells. There is no postorbital process to the frontal, so that the orbit is not divided from the temporal fossa. There is a conspicuous, rough, antorbital projection on the lacrymal bone just in front of the lacrymal foramen. The nasals are very large and strong, early ankylosed together, arched from before backwards, and pointed anteriorly. The most elevated part of their upper surface is roughened, and supports the great median horn which characterises the genus. In some species a posterior rough, but less elevated, surface indicates the attachment of a second horn. In some of the extinct species the mesethmoid cartilage was ossified nearly as far forwards as the extremity of the nasals, which is not the case with any existing species. The premaxillæ are very small, and do not extend anteriorly beyond the level of the front end of the nasals. The hinder border of the palate is deeply excavated, the horizontal plates of the palatines being very narrow. The pterygoids are very slender, as in the Horse, but placed more vertically. There is a distinct alisphenoid canal. The squamosal sends down a very long, conical, postglenoid process parallel with, and equalling, or sometimes exceeding, in length, the paroccipital process. In all existing two-horned species (*R. sumatrensis*, *bicornis* and *simus*) the meatus auditorius lies in a deep groove between the post-glenoid and the post-tympanic processes of the squamosal. In the one-horned species (*R. unicornis* and *sondaicus*) these processes unite below so as to completely surround the meatus. The post-tympanic process articulates with the exoccipital, completely excluding the mastoid from the external surface of the skull.[1]

The tympanic and periotic are ankylosed together, but not with the squamosal. They are both very small. The under surface of the tympanic is rough, forms no distinct bulla, and is much encroached upon posteriorly by the very large tympanohyal, which presents a circular, slightly concave, rough, inferior surface, half an inch in diameter (in an adult Sumatran Rhinoceros). Externally, the tympanic is produced into a rough, irregular, inferior wall to the auditory meatus. The periotic internally shows the internal auditory meatus near its lower part, but no distinct depression for the flocculus; it is prolonged upwards and outwards into a small mastoid portion, which, as before said, does not appear on the outer surface of the skull.

The mandible has a very wide condylar articular surface, and slender recurved coronoid process, a rounded, somewhat incurved angle, a compressed, rather narrow, horizontal portion, and a shallow depressed symphysis.

[1] See W. H. Flower, "On some Cranial and Dental characters of the existing species of Rhinoceros." (Proc. Zool. Soc. 1876.)

The hyoid is much like that of the Horse, and has a glossohyal process from the middle of the basihyal.

The Tapirs present some singular modifications of the same type of skull.

As in the Rhinoceros, there is no separation between the orbit and temporal fossa, but the anterior nares are of immense size, and extend backward above the orbits, being separated from them only by a thin plate of bone instead of a broad flat surface, as in the Horse and Rhinoceros. The nasal bones are short, broad behind, pointed in front, much elevated, and supported by a tolerably well ossified mesethmoid, which spreads out laterally at its upper end.[1] The inferior and lateral margins of the great narial apertures are entirely formed by the maxillæ, which extend up to meet the nasals, the premaxillæ not taking any share in them. The ethmo-turbinals are small, while the maxillo-turbinals, on the other hand, are very extensive, though their plications are comparatively simple. A conspicuous feature in the upper part of the face is a groove, which extends backwards on the side of the dilated hinder end of the nasal bone, and curves inwards to form a rounded depression over the naso-frontal suture. The form and size of this depression vary in different species. It lodges an air sinus, with cartilaginous walls extending upwards from the nasal chamber. In front of the nares the rostrum formed by the maxillæ with the premaxillæ in front is produced, compressed anteriorly, and curved downwards.

The base of the cranium resembles generally that of the other *Perissodactyla*. There is an alisphenoid canal, and

[1] In one species (*T. Bairdii*) the ossification of the mesethmoid extends far in advance of the nasal bones, and is clasped and supported below by ascending plates from the maxillæ.

deltoid ridge is an extremely salient, compressed, and everted tuberosity.

In the fore-arm the two bones are nearly always distinct, though closely applied to each other. The breadth of the upper end of the radius, and the amount of rotation permitted upon the ulna, vary much in different genera.

In the great order UNGULATA the humerus is stout and rather short. The outer tuberosity is very large, and generally sends a strong curved process inwards, overhanging the bicipital groove (not, however, in the Horse and Camel). The deltoid ridge is usually not strongly marked, and placed rather high on the bone; but in the Rhinoceros it is a very salient ridge. The lower end is always particularly straight and flat on the inner side (see Fig. 89, p. 273), the condyle forming no prominence, and there is never a supracondylar foramen. The outer condyle and the ridge above it are rather more developed.

The radius is large at both ends, and superiorly extends across the whole of the humeral trochlear surface (see Fig. 89). The ulna is a complete and distinct bone in the Pig, Hippopotamus, Tapir, and Rhinoceros. In the Ruminants it is more or less rudimentary and fixed behind the radius. In the Camel the two bones become completely coalesced. In the Horse the olecranon and proximal part of the shaft alone remain, firmly ankylosed to the radius.

In the PROBOSCIDEA the humerus is remarkable for the great development of the supinator ridge. The ulna and radius are quite distinct, and permanently crossed. The upper end of the latter is small, while the ulna not only contributes the principal part of the articular surface for the humerus, but has its distal end actually larger than that of the radius, a condition unique among Mammals.

In Hyrax the humerus is straight, with a very prominent outer tuberosity, moderate deltoid ridge, rather compressed inferior extremity, large supratrochlear, but no supracondylar, perforation. The ulna and radius are complete and subequal, often ankylosing together in old animals.

In the CETACEA, the bones of the arm and fore-arm are usually very short, broad, and simple in their characters (see Fig. 103). The humerus has a large globular head, which moves freely in the glenoid cavity of the scapula, the tuberosities are fused into one, the bicipital groove being absent: the lower end is broad and flattened, and its inferior surface is divided into two nearly equal flat surfaces placed side by side (one external, the other internal), and meeting at a very obtuse angle. The equally flat upper surfaces of the radius and ulna are applied to these, and so united that scarcely any motion is permitted between them, and often in old animals ankylosis takes place at the joint.

The ulna and radius are parallel to each other without any indication of crossing: the former has a tolerably well-developed olecranon process projecting directly outwards from the shaft of the bone: the radius is extremely simple in form, wider distally than proximally.

In the Rorquals (*Balænoptera* and *Megaptera*) these bones are considerably elongated.

In the SIRENIA the bones of the fore-limb are formed on a different type, as there is a distinct, though small and simple, trochlear articulation at the elbow-joint. In the Dugong, the humerus is small in the middle of the shaft, and expanded at each end. The tuberosities are very prominent, especially the outer one, and the bicipital groove is distinct. The internal condyle is prominent, the anconeal fossa small, and there is no supracondylar perforation. In is reduced to a short metacarpal; the fifth digit has but two phalanges, and the centrale is united with the trapezoid. The ungual phalanges of the three middle digits are small and somewhat conical in form.

In the Elephant (Fig. 98) the manus is short and broad, the carpal bones are massive and square, and articulate by very flat surfaces; they consist of scaphoid, lunar and cuneiform, a pisiform and the usual four bones of the distal row, all distinct, without the centrale. There are five digits, with short stout phalanges, the terminal ones being very small and of irregular form.

All the existing true Ungulate Mammals agree in the complete suppression of the pollex, in the absence of an os centrale, and in the complete separation of the scaphoid and lunar. The carpus is very compact, the bones being generally more or less square, and articulating by flat surfaces with each other, and with the radius and ulna above. The second or distal row of the carpal bones has, in comparison with the Subungulata, been shifted altogether towards the radial side of the limb, so that the os magnum is brought considerably in relation with the scaphoid, and is entirely removed from the cuneiform as in the great majority of existing Mammals. The axis of the third toe passes therefore through the os magnum but between the lunar and scaphoid. The Ungulata are eminently digitigrade, the limb being (except in the *Tylopoda*) entirely supported on the ungual phalanges, which are large, and encased in a hoof.

The digits are arranged according to one or the other of two distinct types, each characteristic of, and giving name to, one of the sub-orders.

1. The *Perissodactyla*, or "odd toed" Ungulates, have the middle or third digit the longest, and symmetrical in itself, the free border of the ungual phalanx being evenly rounded.

The second and fourth toes may be subequally developed, as in the Rhinoceros (Fig. 100), or they may be represented only by mere splint-like rudiments of their metacarpals, as in the Horse (Fig. 101). All intermediate conditions are met with in various extinct forms, as *Palæotherium*, *Anchitherium*,

FIG. 99.

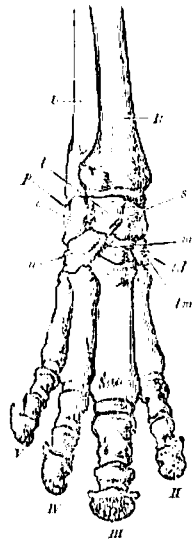

FIG. 100.

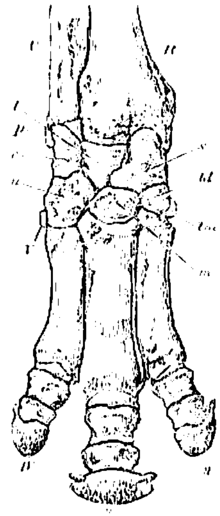

FIG. 101.

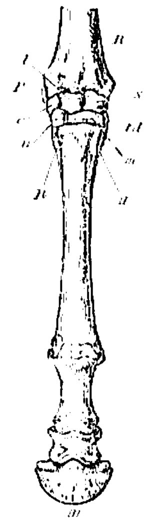

FIG. 99.—Bones of the manus of Tapir (*Tapirus indicus*), [illegible].
FIG. 100.—Bones of the manus of Rhinoceros (*Rhinoceros sumatrensis*), [illegible].
FIG. 101.—Bones of the manus of Horse (*Equus caballus*), [illegible]. II and IV rudimentary metacarpals.

and *Hipparion*. In the Tapir (Fig. 99) there are four complete toes, in consequence of the fifth being developed, though it scarcely reaches the ground in walking. In other respects the foot resembles that of the Rhinoceros, the third toe being longest, and symmetrical in itself and having on each side of it the nearly equal second and fourth. In the Rhinoceros there is a rudiment only of the fifth metacarpal.

In the Horse (Fig. 101), the three bones of the first row of the carpus are subequal. The second row consists of a very broad and flat magnum (*m*), supporting the great third metacarpal, having to its radial side the trapezoid (*td*), and to its ulnar side the unciform (*u*), which are both small, and articulate distally with the rudimentary second and fourth metacarpals. The pisiform is large and prominent, flattened and curved; it articulates partly to the cuneiform, and partly to the lower end of the radius. The single digit consists of a moderate-sized proximal, a very short middle, and a wide, semilunar, ungual phalanx. There is a pair of large nodular sesamoids behind the metacarpo-phalangeal articulation, and a single, transversely extended, "navicular" sesamoid behind the joint between the second and third phalanx.[1]

2. The *Artiodactyla* have the third and fourth digits almost equally developed, and their ungual phalanges flattened on their inner or contiguous surfaces, so that each is symmetrical in itself, but when the two are placed together they form a figure symmetrically disposed to a line drawn between them. Or, in other words, the axis or median line of the whole manus is a line drawn between the third and fourth digits, while in the Perissodactyles it is a line drawn down the centre of the third digit.

In the *Suina*, Pigs (Fig. 102), Peccaries, and Hippopotamus,

[1] With reference to the interesting cases of atavistic polydactylism, see Gegenbaur's "Critical Remarks on Polydactyly as Atavism," Journ. of Anat. and Physiol. xvi. p. 615; Boas, "Bemerkungen ueber die Polydactylie des Pferdes," Morphol. Jahrb. x. p. 182. By far the larger number of cases of polydactyly in the Horse as in other Mammals, are merely due to a teratological multiplication of digits, and are not reversions to an ancestral condition, as frequently supposed.

the second and fifth toes are well developed, though always considerably smaller than the third and fourth, all four metacarpal bones are distinct, and the manus is comparatively broad. The second row of carpal bones in the Pig consists of a small trapezoid, a moderate-sized magnum,

FIG. 102.

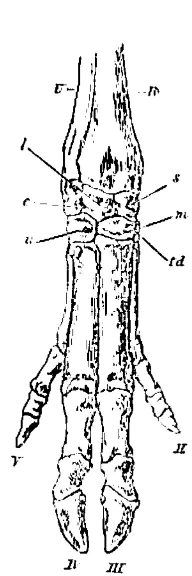

FIG. 103.

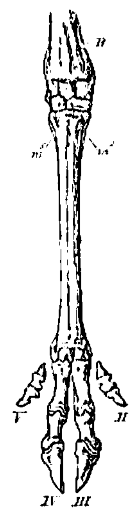

FIG. 104.

FIG. 102.—Bones of the manus of Pig (*Sus scrofa*). ⅓.
FIG. 103.—Bones of the manus of Red Deer (*Cervus elaphus*). ⅓.
FIG. 104.—Bones of the manus of Camel (*Camelus bactrianus*). ⅓.

and a large unciform. In the Hippopotamus there is also a trapezium.

In the ruminating sections of the sub-order (Figs. 103 and 104), the third and fourth metacarpals, though originally distinct, become more or less conjoined, generally so as to

Among the INSECTIVORA, the Hedgehog has a strong ridge distally from the great trochanter of the femur, and several other forms have a similar rudiment of a third trochanter. As a general rule the fibula is slender, and in its distal half ankylosed with the tibia, but it is complete and distinct in the genera *Galeopithecus*, *Tupaia*, *Centetes*, *Ericulus* and *Solenodon*.

In the CHIROPTERA, the femur is slender and straight, with trochanters of nearly equal size, and with a small globular head, set on a very short neck, with its axis pointing almost directly to the anterior or dorsal surfaces of the bone. The fibula varies in condition; in the *Molossinæ* alone it is well developed. In all other species it is either very slender or ligamentous in its proximal third (*Pteropus*), reduced to a small bony process above the heel, as in *Megaderma*, or altogether absent, as in *Nycteris* (Dobson).

In the RODENTIA the femur varies much. In the Hares and Squirrels it is long and slender, with a third trochanter immediately below the great trochanter. In the Beaver it is broad and flat, and has a strong ridge about the middle of the outer side of the shaft. In many other forms (*e.g.* *Hystrix*) neither of these accessory prominences exist, but the great trochanter is usually much developed.

In *Myopotamus* and still more in *Capromys* there is a strong ridge on the inner side of the middle of the shaft, indicating the point of insertion of the adductor muscles.

In some forms, as the Beaver, the fibula is distinct, strongly developed, and separated from the tibia, except at the extremities, by a wide inter-osseous space. In others, as the Hares, it is slender, and in its distal half united with the tibia. The patella is generally elongated, fabellæ are usually developed, and there are often wedge-shaped ossifications in the semilunar cartilages of the knee-joint.

In the UNGULATA, the femur is rather compressed, especially at the lower end. There is no distinct constriction of the neck, separating the head from the rest of the bone. The great trochanter is very large, and usually rises above the level of the head. The small trochanter is not very salient, and sometimes, as in the Rhinoceros (Fig. 118), is a

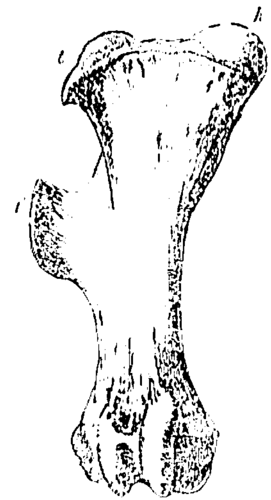

FIG. 118.—Anterior aspect of right femur of Rhinoceros (*[illegible]*) [illegible]. *h* head; *t* great trochanter; *t'* third trochanter.

mere rough ridge. The inner edge of the anterior part of the inferior articular surface is very prominent. In all the Perissodactyles there is a strongly marked third trochanter (*t'*), in the form of a compressed ridge curving forwards. This is entirely absent in all the known Artiodactyles.

The fibula is subject to great variations among the different members of the order. In the Rhinoceros, Tapir, Pig, and the heel being raised from the ground, and the metatarsal segment usually much elongated. There is no trace of a hallux in any existing species. As in the corresponding segment of the fore limb, the pes is formed upon one or other of two distinct types, each characteristic of one of the sub orders.

In the *Perissodactyla*, the third digit is the largest, in the centre of the foot, and symmetrical in itself; the second and fourth are smaller, and nearly equal in length, though sometimes quite rudimentary. A line drawn through the centre of the foot passes through the axis of the third digit, and the middle of the external cuneiform, navicular, and astragalus. The distal surface of the astragalus has a large articular surface for the navicular, and a very small one for the cuboid, which bone is of comparatively less importance than in the Artiodactyla. The calcaneum does not articulate with the lower end of the fibula.

The Rhinoceros (Fig. 126) and Tapir have all the usual bones of the tarsus well developed. The internal cuneiform has a curved process projecting backwards. The middle cuneiform (c^2) is very small. The whole foot is comparatively short and broad. The second and fourth toes are well developed, being nearly as long as the middle toe. The phalanges resemble those of the fore limb. In the Tapir the pes differs from the manus in wanting the fifth digit.

In the Horse (Fig. 127), the middle toe is greatly enlarged, and the second and fourth reduced to slender styliform metatarsals, about three-fourths the length of the second, but supporting no phalanges. The navicular (*n*) and the external cuneiform (c^3) are very broad and flat. The cuboid (*cb*) is small, and the internal and middle cuneiform bones are small and united together.

Various gradational stages between the complete tridactyle foot of the Rhinoceros and the monodactyle foot of the Horse are met with in extinct species of the Perissodactyla.

In the *Artiodactyla* the third and fourth digits are nearly equally developed, and their ungual phalanges are flattened on their contiguous sides, so that together they constitute a

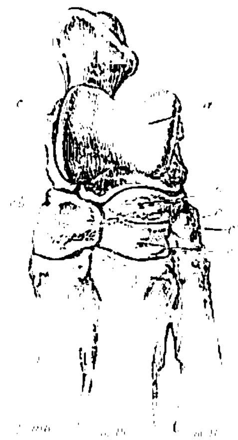

FIG. 126.—Dorsal surface of right tarsus of Rhinoceros (*Rhinoceros sumatrensis*). ⅓.

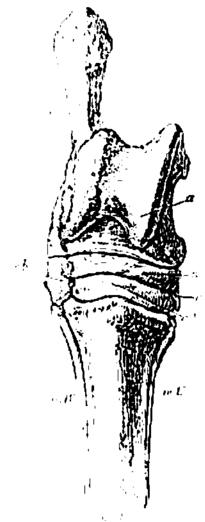

FIG. 127.—Dorsal surface of right tarsus of Horse (*Equus caballus*). ⅓.

symmetrical form. The second and fifth toes, when present are also equal, but smaller than the others. A line drawn through the centre of the foot has on its tibial side the third digit and metatarsal, the external cuneiform, the navicular and half the astragalus; and on its fibular side the fourth digit and metatarsal, the cuboid and the other half of the