The
PHYSICAL FEATURES OF LAKE CALLABONNA*

By E. C. S'l'IRLING, C.M.G., M.A., M.D., F.R.S., C.M.Z.S.,
Director South Australian Museum.

Plate A

[Read July 3, 1900]

[By permission of the Editor, for which the Author desires to record his acknowledgment and thanks, the following article is, with some modification, reprinted from" Nature," vol. I., pp. 184 and 206.]

As has often been observed, those who might form their estimate of the physical geography of the interior regions of South Australia from an inspection of its maps alone would come to very erroneous conclusions. The numerous and, often, immense areas marked as lakes, and the plentiful streams which appear to supply them, deserve their names on rare occasions only. Ordinarily the lakes are shallow, mud-bottomed or silt-encrusted claypans only, and the rivers dry water-courses, or it may be, even, that no definite channels for the latter are recognisable amidst the flats which in flood time they overflow. Only after the heavy tropical rains, which at too rare intervals descend to these latitudes, do the rivers run for a brief period and the lakes contain water, though for some time afterwards the deeper parts of the water courses may remain as water-holes, or chains of water-holes, of greater or less size and permanence. There, however, who have only seen the river channel dry can havc little idea of what torrents they may become under such circumstances. The flood-waters of the Barcoo or Cooper some few years ago spread over a breadth of from forty to fifty miles on its way to reach Lake Eyre. Lake Eyre itself has occasionally been filled, and is then a vast inland

---

*It may be well to state, perhaps, that the so called Lake in which the fossils were found has been hitherto usually spoken of as Lake Mulligan. That name, however, has never been officially conferred or recognised, and, indeed, it will not be found on any of the maps of South Australia. There prevails a very proper sentiment, unfortunately not always carried into action, that the native names of localities should as far as possible be retained. In this particular instance the euphonious native name Callabonna, which applies to a large watercourse leading into the Lake and to an adjoining sheep run, seemed appropriate in all respects, save that the association of sound and idea might erroneously suggest the possession of scenic beauties by an area which is not only waterless, but also almost unsurpassable for barrenness and utter desolation. The name suggested by the writer, however, has been applied by the South Australian Executive, and in future the locality is to be known officially as Lake Callabonna., and will be so called in the following notes.

sea over a hundred miles long and fifty broad, and when full of water might well have suggested, as it actually did suggest, great possibilities of internal navigation.

The area of these inland lakes presents roughly a division into a Western system, comprising Lake Gairdner and numerous adjacent smaller clay pans; a Central, of which Lake Eyre, Lake Eyre South and Lake Torrens are the chief members; and an Eastern, comprising, in their order from north to south, Lakes Gregory, Blanche, Callabonna and Frome. These three systems have no direct communication with one another-in fact, they are - separated by more or less elevated ground.

From the fact of some of the early explorers, in proceeding northwards, having struck the apparently unending margins and impassable beds of the huge claypans either of Lake Torrens, of Lake Eyre, or of those of the Eastern group, all of them were for some time supposed to be continuous and to form one great lacustrine surface. Indeed, for many years a familiar feature on the maps of Australia was an immense crescentic or horse-shoe shaped lacustrine area, with its two horns, formed by the present Lakes Torrens and Frome, directed south-wards. Eventually the progress of discovery enabled this horse-shoe to be broken up into the constituents now separately delineated as Lakes Torrens, Eyre, Gregory, Blanche, Callabonna and Frome. It is easy to see, on reference to a recent map, how great the chances were that explorers, having once passed into the unknown enclave of this great system of claypans, should have had their further progress checked at the shores of one or other of them.

The constituents of the Eastern system, with which we are more immediately concerned, form a chain of clay-pans connected by intervening channels and, together, they present a curve with its concavity directed towards the west. The whole of the series is, according to the most recent maps, included between the meridians of longitude 138^0 50' and 140^0 20' east of Greenwich and the degrees of south latitude 31^0 12' and 28° 50'.

On those rare occasions when the flood-waters of the Barcoo come down in sufficient volume, from the immense area which it drains in South- Western Queensland, they overflow into the large effluent channel known as Strzelecki, which leaves the main river bed at Innamincka·-a place of melancholy memory in the history of Australian discoveries, for close by the present settlement lie the remains of the ill-fated Burke who perished in 1861, after a successful transit of Australia-and they may then fill Lakes Gregory and Blanche. The latter lake, indeed, was filled in 1892, when its waters remained fresh for six months. A channel from the Strzelecki leads into Lake Callabonna, and I am informed that this depression also was filled from the same source some years ago, a statement which is supported by-the presence upon the sandhills of numerous fragments of the eggs of fresh-water fowl and of bones of water rats *Hydromys).* On the older maps Lake Callabonna was depicted as a northerly extension of Lake Frome -and, indeed, these two are actually connected by a channel- but whether water has ever been known to flow from one into the other I have not been able to learn.

There is, however, compensation for the unpromising physical features of Lake Callabonna in the field that its bed proves to be a veritable necropolis of gigantic extinct marsupials and birds which have apparently died where they lie, literally, in hundreds. The facts that the bones of individuals are often unbroken, close together and, frequently, in their proper relative positions *(vide* pl. A, fig. 3)), the attitude of many of the bodies; and the character of the matrix in which they have been embedded, negative any theory that they have been carried thither by floods. The probability is, rather, that they met their death by being entombed in the effort to reach food or water, just as even now happens in dry seasons, to hundreds of cattle which, exhausted by thirst and starvation, are unable to extricate themselves from the boggy places that they have entered in pursuit either of water or of the little green herbage due to its presence. The accumulation of so many bodies in one locality points to the fact of their assemblage around one of the last remaining oases in the region of desiccation which succeeded an antecedent condition of plenteous rains and abundant waters. An identical explanation has been suggested by Mr. Daintree* in his "Notes on the Geology of the Colony of Queensland."

Lake Callabonna, the description of which is, in its main features, applicable to its kindred claypans, has a length of over fifty miles. About ten miles wide at its northern extremity, it narrows to four or five at the site of the recent excavations, which is some fifteen miles to the southward, and becomes still further constricted in the remainder. Its shores, especially on the Eastern side, are as yet imperfectly surveyed, nor have, I believe, any levels been taken of its bed. Possibly, like Lake Eyre, it may actually be below the sea level, but in any case it is relatively low-lying, for water-courses lead into it on three sides. The Mount Hopeless, Yerila, Woratchie, Hamilton, Parabarana and Pepegoona Creeks, all of which rise in the Flinders Range, enter it on the western side; and the Callabonna and Yandama Creeks, rising in the Grey Range, on the east. Though these only run after heavy rain, they may then bring down a considerable quantity of flood-water. As already indicated, water can flow into the Lake at the northern end by the Moppa-Collina Channnel from the Strzelecki. The occasional character of the surrounding country may be best appreciated by reference to some of the names given by the early explorers and settlers, such as Mount Hopeless, Dreary Point, Illusion Plains, Mount Deception, Mirage Creek, which tell their own story of drought, difficulties and disappointments.

Speaking generally, the bed of the Lake is a great flat claypan, depressed but very little below the surrounding country (pl. A, fig. 1). In the neighbourhood of the fossiliferous area, however, this prevailing flatness is broken by the existence of an aggregation of dunes or hillocks of fine drift sand, not exceeding thirty feet in height, having their ridges running more or less north and south or' at right angles to the direction of the prevailing easterly winds. These dunes are so far discontinuous that, did the Lake contain a very few feet of water, they would be converted into a number of irregularly shaped sand islets.

---

*Quart, Journ. Geol.Soc, volXXVIII, 1872, p 275

From a foot to eighteen inches below their surface is a layer of loosely compacted sand-rock, in which were found the bivalve *Corbicula desolata*, Tate, now living in the Cooper River system, and the univalve *Coxiella gilesi,* Angas sp. *(Blanfordia stirlingi,* Tate).

The sand-dune area is about four miles long from north to south and about three miles wide. The camp of the working party was at first pitched on the east side of the most southerly hillock, but the extreme exposure of the site to the prevailing wind and sandstorms soon compelled a change to the opposite side. Northwards of the sandhills, as far as the eye can reach, the whole Lake-bed is an unbroken flat expanse, covered 'with gypsum crystals of all sizes, from which the reflection of the bright sunlight causes a painful glare to the eyes. The greatest distance in this direction reached by members of the working party was eight miles. Hero there are a number of brackish springs in the bed of the Lake, each surrounded by a fringe of bulrushes *(Typha angustifolia),* and on the way thither a peculiar oval mound was passed, consisting of an interior mass of black soft mud, covered by a greyish crust, the whole structure quaking on pressure like a jelly. The size was about twelve feet long by eight broad and four high.

South of the camp is another flat expanse on which water very readily collects even after a light fall of rain. When this is dry the surface is white, from the presence of a saline efflorescence, probably sulphate of sodium. To the east and west the group of sandhills are separated from the mainland by salt-encrusted flats which, in dry weather, are passable for camels and even for light vehicles, but extraordinarily boggy and sticky after rain.

There are a few shallow water-courses near the camp, the general direction of which is from north to south, and in some parts of these salt water stands permanently. The soft black mud which forms their bed contains in many places much decomposing vegetable matter, and often stinks horribly from the evolution from it of sulphuretted hydrogen gas. In one place there is, in the bed of the water-course, a round black-looking hole standing full of water, which gave no bottom with soundings at 25 feet.

After a continuance of dry weather the flats around the camp become coated with H, white amorphous saline crust, having the peculiarity that it does not form on surface tracks, and as these then appear dark amidst the surrounding white ground, the scene suggests with singular force the appearance of footprints on a snowfield. On the other hand, whenever water, collected after rain in tracks and other indentations, has evaporated, which very soon takes place under the influence of the strong dry winds of the locality, there are left behind large flat glistening prismatic crystals of sodium sulphate, which in excess of dryness crumble into a fine white powder.

Scarcely any vegetation relieves the prevailing desolation beyond stubbly samphire plants *(Salicornia)* which grow in patches upon the sandhills and rarely exceed two feet in height. Judging by the unusual thickness of their stems, some of these bushes must be very old. A few scattered and still more stunted bushes of the same plant grow upon the intervening flats. To the north and south of the sandhills not a bush relieves the unbroken monotony of the level white crystalline surface.

On the western side, not far from the margin of the Lake are the Mulligan Spings, where a station hut was formerly in occupation, but this has been for some time abandoned. The adjacent country is now under pastoral lease to the Beltana Pastoral Company, whose holding extends continuously to the westward for a distance of l50 miles. The eastern spurs of the Flinders Range, the highest summit of which reach an elevation exceeding 3,000 feet, approach to within about twenty miles of the Lake; and, at Paralana, on the eatsern slope of the Range, there are hot springs. Callabonna Station, belonging to Messrs Ragless Brothers, borders the Lake on the east, and consists chiefly of sandy plains which stretch to, and beyond, the boundary of New South Wales. The station-house stands on Callabonna Creek, about four miles from the Lake and six from the camp. Further south is the Muloowurtina Station, belonging to Mr. D. McCallum. The distance from Adelaide in a direct line is about 400 miles, but to reach the Lake by the ordinary routes necessitates a journey by rail of about that length and an additional 150 to 200 miles by road, according to the route selected. The whole journey thither occupies five to six days, or longer in bad seasons.

Such are the physical characters of this uninviting region; its geological features will be afterwards considered.

HISTORY OF THE DISCOVERY

During many years and from many parts of South Australia, notably from the Lake Eyre District, the South Australian Museum has from time to time received teeth and fragments of Diprotodon bones, which were occasionally associated with fragmentary remains of macropods, crocodiles, turtles and large birds.

Amongst such donations were some teeth and portions of the lower jaw sent to us, in 1885, by Mr John Ragless, which were found by his son, Mr. F. B. Ragless, in a watercourse at a depth of five feet, about two miles east of the margin of Lake Callabonna and about twelve miles north-east of the place where the more recent discoveries have been made. It was not, however, until 1889 that the Museum obtained a fairly perfect skull and several other bones in their entirety from Baldina Creek, near Burra, a locality about a hundred miles due north of Adelaide. In the same year, from fragments found at Bundey, in the same district, we were able to restore, incompletely, another skull considerably smaller than the former. A little later a third, but more imperfect, skull was found at Gawler, 25 miles north of Adelaide.

Since the first discovery of Diprotodon remains in the Wellington Caves by Sir Thomas Mitchell, in 1830, teeth and bones of this animal have been found over an extensive area, which extends from the Gulf of Carpentaria to Victoria and from the Darling Downs to the Lake Eyre Basin. They have also been found at Kimberley in North-Western Australia, and to the west of the head of the Great Bight, so that this great marsupial appears to have had an immense range and to have probably wandered over the whole Continent of Australia.

The existence of bones in the actual bed of Lake Callabonna was made known to Mr. F. B. Ragless on the 10th January, 1892, by an intelligent aboriginal, who described them as being very large and numerous, and two days afterwards Mr. Ragless himself visited the locality which afterwards became the seat of operations. A few days later the place was visited by John Meldrum, who had been for some months in Mr. Ragless's employ and by him some fragments were brought to Adelaide. These facts having been brought under the notice of the Museum Authorities, Mr H. Hurst, who had previously had some experience in geological and paleontological work in Queensland, was commissioned to inspect and report. The promising nature of the report of this gentleman ultimately led to the despatch to the Lake of a party under his charge in January, 1893.

Operations under Mr. Hurst's superintendence were continued for four months, during which time a considerable amount of material was obtained. Towards the end of June, however, the work, having been previously interrupted by rain, had to be finally discontinued in consequence of a heavy fall, and Mr. Hurst, with one of his party, returned to Adelaide, bringing with him as many bones as could be carried in a "buck-board" buggy.

At this stage it appeared desirable for various reasons that the Work of excavation should be continued under the direction of a responsible Museum Officer, and accordingly, at the desire of the Board of Governors, I left for the field on the 11th August, 1893, in company with Mr. Zietz, the Assistant-Director, and another member of the Museum staff. On our arrival at Lake Callabonna, Mr. Hurst (who had by that time returned to the camp) resigned his appointment as well as another member of his original party.

As the result of Mr. Hurst's labours a quantity of bones were shortly despatched to Adelaide. Soon after our own arrival a fall of rain, though not exceeding half an inch in amount, was sufficient to cause considerable sheets of water to collect on the low-lying flats, to fill up the holes which had been excavated, and to render the clay surface of the Lake, at the best of times very soft and sticky, so boggy that further work on the field became for a time impossible. Further, it became a matter of great difficulty for the camels to pass over to the mainland for the requisite supplies, and it was occasionally necessary to remove their loads and dig them out of the glue-like mud in which they had sunk nearly to their bellies.

In consequence of the rain it was a fortnight before excavations could be properly resumed; meanwhile, being obliged by other duties to return to Adelaide, I left the camp in charge of Mr. Zietz, the other members of the party being three assistants and a cook, with two Afghans in charge of five camels. The absence of all feed near the camp rendered it necessary that these latter should have their encampment on the eastern shore, at a distance of about two miles and a half.

The number of the party thenceforth remained unchanged.

Without the camels, which were lent to us by the liberality of the South Australian

Government, it would have been quite impossible to carry on the work. By them meat, which sometimes went bad before the day was out, had to be brought a distance of six miles from Callabonna Station and water from the same place, until, with the advance of summer, the station supply fell short, when it became necessary to send to a well at a still greater distance; every stick of firewood, also, had to be fetched several miles. From the ravages of rabbits, of which there will be more to say directly, it was difficult to keep the camels in sufficiently good condition for their work, and each journey for wood and water generally required two days.

When, in the course of a fortnight after the rain, the ground had sufficiently dried to permit of the excavations being resumed, operations were commenced by Mr. Zietz at a place about a mile north-west of the camp from which his predecessor, Mr. Hurst, had obtained a number of bones. The subsequent yield, however, was inconsiderable in quantity, and such as were found were much broken and decomposed. They represented, however, a variety of. species-odd bones of large and small Diprotodons, of the large wombat (*Phascolonus gigas)**, of kangaroos and of birds, all these being sometimes mixed together in great confusion; or it might be that the bones of apparently a single Diprotodon, even in previously unopened ground, were widely separated and broken, the fractures being sharp and the missing pieces not discoverable.

This locality was consequently abandoned in favour of parts nearer the camp; from these good results were continuously obtained, and amongst them one apparently nearly complete Diprotodon skeleton: which was found in ground that had been tramped over hundreds of times in going to and fro between the camp and the more distant workings. Here also the remains of four birds# were found lying close together. It may be mentioned that underground bones were usually discovered by probing with a wire rod, the sense of touch easily detecting the impact even with those that were soft.

CHARACTER OF THE LAKE BED

The Lake bed in the fossiliferous area adjacent to the camp comprises what appears to be one of its most low-lying parts. Its superstratum is a layer of stiff yellowish clay of variable depth, but usually of not less than about a foot in thickness, not of uniform character, but marked by streaks 01' veins of a rusty colour, containing much fine sharp sand, due apparently to surface cracks having been filled up with drift-sand.

In some places this veining is so irregular and contorted as to give the clay a marbled appearance. On drying the clay separates readily, along these streaks, into quadrangular or polygonal masses, somewhat after the manner of coal.

Beneath this superstratum is a layer of unctuous blue clay, of about two feet in thickness, resting upon a band of coarse sharp sand beneath which no bones were ever found by MI'. Zietz. Below the sand the same blue clay occurs again for an undetermined depth, and

---

* *Vide* Trans. R. Soc, of South Australia, vol. XXIII" p. 123.

Genyornis newtoni, Vide Trans, R. Soc. of S. A., vol. XX., pp, 171 and 191; also these Memoirs, vol. 1. (part 2), p. 41.

shows in parts a laminated structure, with salt-water lying in the interlaminar spaces. The greatest depth actually reached in digging was between six and seven feet.

On physical analysis this clay yielded 15-20 per cent. of fine sharp quartz-sand, while an approximate chemical analysis, kindly made for me by the late Mr. Turner, Demonstrator of Chemistry in the University, yielded the following results :-

Water	13
Silica	40
Calcium carbonate	8 5
Alumina and iron	11 3
Magnesia	1.5
Alkaline chlorides and sulphates (mainly sodium sulphate)	25.7
Total	100

In the dry state numerous minute crystals of sulphate of calcium were visible in the clay.

In the least low-lying parts of the area salt-water is reached at from two and a half to three feet; in the most depressed it remained permanently on the surface during the whaIn period of the excavations, which extended over the dry months of August, September, October, and November. In parts which are neither the highest nor the lowest the surface clay remains merely damp, and it was in ground of this character that the bones in best condition were found, provided that the underlying water did not approach the surface too nearly. In such cases and in the very low places where the water remained permanently on the surface it was impossible to excavate on account of the excessive inflow into the holes.

GEOLOGY

For what I have to say under this head I must express my obligations to my colleague, Professor Tate, whose observations in Australia have now extended over many years and have covered a large area. He has recently summarised the whole history of its geological progress in a very able inaugural presidential address to the Australasian Association for the Advancement of Science*, and I have had no hesitation in quoting freely from this and from other writings of so competent an observer.

There appears to be no doubt, both from geological and biological reasoning, that in the Upper Cretaceous period a great part of Central Australia was covered by a sea which extended from the Gulf of Carpentaria to the Great Bight, and so divided the continent into an easterly and western moiety. Following this, an upheaval of the sea-covered area took place, succeeded by a denudation of the Cretaceous deposits. Unequal movements of depression then brought about lacustrine conditions on portions of the now uplifted bottom of the old sea strait and, in other portions, permitted of the admission of the waters of the ocean.

*Adelaide 1893

Finally a general upheaval, followed by utter desiccation, placed the deposits of the period just concluded ill nearly the condition in which we now find them.

The system of existing lakes which have been mentioned in an earlier part of this article are evidently the shrunken remainders of the much larger lacustrine area of Pleistocene times -a. condition which demanded for its existence a much greater rainfall than now exists. The region of Lake Eyre was then, as now, the centre of the inland continental drainage. Towards this depression are directed many dry watercourses, of which those of the Macumba, Finke, Cooper and Diamantina are the chief. For miles around extends an area of sandhills, separated by loamy interspaces, which are litoral sandbanks marking the successive changes in the contraction of the waters. Within its basin the Pliocene sands and loams have yielded further proof of its lacustrine origin in the remains of Diprotodon, turtle, crocodile, and ceratodus.

In Professor Tate's opinion, Lake Torrens may have belonged to a lacustrine area, distinct from that of Lake Eyre, at least, with the existing contour of the country, a submergence of at least 400 feet would be necessary before the two systems could be connected.

Such a submergence would also unite in a vast inland sea the whole of the lake region around Lake Eyre and to the westward of Lake Torrens. A very much less considerable submergence would connect Lake Eyre with Lake Frome and the lakes to the north of it. Much of the Murray Desert to the eastward of Overland Corner and perhaps the whole Riverine region was at this time a lacustrine area, though probably disconnected from those of Lakes Eyre and Torrens.

The following table, based on Mr. Hurst's report and revised by Professor Tate, represents approximately the classification of the formations of the district :-

Recent.-Loose sand, generally forming low ridges; sandhills or dunes overlying in places the Plestiocene beds.

Pleistocene-Lake Callabonna; fossiliferous formation. Bands of unctuous blue clay, containing abundant quantities of saline minerals and concretions of carbonate of lime; thin seams of sand; inflorescent deposit of salts upon the surface. Fossils.-Extinct mammalia, birds, a fresh-water mollusc *(Potamopyrgus sp.),* Entomostracans and a few plants of living species *(Charae}* and *Callitris robusta).*

Mesozoic-(*a)* "Desert sandstone" or Post-Cretaceous (hard quartzites or porcellanized sandstone, gritty sandstones and conglomerates). *Fossils* -Dicotyledonous leaves. *(b)* " Rolling downs" formation or Upper Cretaceous; shales with fossiliferous limestone bands.

Azoic.-Metamorphic schists; clay slates, mica, talc and hornblende slates, metamorphic and intrusive.granite and greenstone.

The Pleistocene formation in which the extinct marsupials occur does not appear to be restricted to the present boundaries of the Lake, as wells, sunk a considerable distance from the pre8ent shore, have yielded fragments of bone in exactly the same formation, thereby showing that the lacustrine area, in Pliocene times, occupied a larger area than at present.

The Mesozoic formation is limited upon the surface to a line of outcrops along the -eastem slope of the Flinders Range. At Parabana, Pepegoona, Hamilton, and Paralana Creeks these beds occur as the edges of an immense mesozoic basin which underlies Lakes Frome and Callabonna. The detritus of this formation forms the stony table-lands and plains of the country, and the, so-called, stony deserts of the early explorers have their origin in the same formation.

The Azoic rocks are restricted to the Flinders Range and are of doubtful age. These rocks were pierced by the Government boring party at Lake Frome several years ago, while boring through the Post-Tertiary and Mesozoic formations in search of artesian water.

FOSSILIFEROUS AREA

The area that has been more or less well explored is not more than 1 mile long by about half to three-quarters of a mile wide, but this forms but a small portion of the fossiliferous ground. Bones were dug up at the springs lying in the Lake bed eight miles to the north of the camp and were observed on the surface in a very weathered condition all along the track thither. In fact Mr. Zietz informs me that traces of bones and teeth exist on the surface in almost every part of the Lake he examined. Nor, as has been said, are they restricted to the present boundaries of the Lake.

SURFACE SKELETONS

One very remarkable feature is the existence of surface skeletons indicated by the presence of concretionary limestone or travertine, which has formed for the bones a sort of cast elevated a few inches above the surrounding level. In some cases the relative position of the bones has been preserved to such an extent that ·the limestone mass presents a striking outline of the form of the skeleton (pI. A, fig. 2). Usually in such cases the animal is lying on its side, with the head and limbs plainly visible and more or less extended. The actual osseous substance has, in many of the bones of these surface skeletons, completely disappeared, but not, however, in all cases; some of them, usually the limb-bones, are more or less imperfectly preserved and devoid of concretion. Several of these surface skeletons existed near the camp at the time of my visit, but Mr. Zietz informs me that after the drying up of the rain which then fell they were no longer visible, having been covered up by the general saline encrustation, which has previously been spoken of.

CONDITION OF THE BONES

The condition of the bones varied very much-some were so friable that they crumbled into powder and could not be removed; others, usually in moist places, were wet, soft and of the consistency of putty. Curiously enough, for reasons which are not clear; some bones from wet places were firm and hard, while others, from ground that was comparatively dry, were soft. As a rule those in best condition came from localities which, without being too wet, were moderately damp. The bones, thus varying in condition and consistency, required very different methods of preparation. The greatest difficulty was undoubtedly due to the circumstance that the bones were saturated with what was practically a concentrated saline solution. In fact, all their cavities were so filled with this fluid that it was necessary to allow a considerable time for it to drain away. In other cases the bones were encrusted and impregnated with gypsum crystals. From such causes the bones became in dry weather brittle and liable to break or crack, and in damp weather difficult to dry. Very careful and patient methods of treatment had consequently to be adopted and will still be necessary until the salt is removed.

When dry the fractured surfaces adhere strongly to the tongue, and an approximate chemical examination by the late Mr. Turner of a clean piece of Diprotodon bone gave the following composition :-

Substance dissolves almost entirely in dilute hydrochloric or nitric acids. Contains

Moisture	3.76 percent,.
Organic matter ...	7.4 "
Inorganic matter, mainly phosphate of lime, with some carbonate	88.84 "
Total	100

POSITION AND ATTITUDE OF SKELETONS

The heads were pointed towards all directions; and the remains of different animals frequently much mixed. Where, however, the bones of an individual were lying in juxtaposition they preserved fairly constant relations to one another. The vertebrae for instance, often formed a more or less continuous series or were broken up into segments, of which the constituents were in such close apposition that they could be removed entire. These bones and the head, which was often much laterally compressed as if by pressure, were usually lying either in their proper position with the dorsal surfaces uppermost or were turned over on their sides. The pelvis was usually horizontal; of the ribs, some were *in situ*, others either widely separated from their fellows or several firmly welded together. The limbs, almost invariably at a greater depth than the rest of the skeleton, had their various segments greatly flexed. The feet were deepest of all. This attitude, together with the frequent approximation of the bones of individual skeletons is, as has been observed, strongly suggestive of death *in situ*- after being bogged (pI. A, fig. 3). A very similar attitude was assumed by the camels on the occasions when they got bogged in crossing from the sand islets to the main land.

Besides the Diprotodon remains,* which form the great bulk of the material obtained, there were collected also a certain number of bones of one or more large kangaroos, including an apparently nearly .complete skull, having a length of 83 cm. The large wombat *(Phascolonus gigas)* has already been mentioned, but its remains were not numerous. Of

.* For what can be said at present concerning the number of species of Diprotodon represented, See Memoirs R. Soc. of S.A., vol. I. (part 1.), pp. 2-4).

Nototherium, so far as we are aware, no traces were found, and the same may be said of Thylacoleo, though careful search for these was constantly made. Bones of the latter animal have, however, been found in other parts of South Australia associated with Diprotodon remains.

No indication whatever was met with of the contemporaneous presence of man.

The four birds whose remains were found close to the camp had their heads all pointing to the south-west, that is towards the part of the lake-bed considered to be the deepest, but their bones, especially the ribs and short bones, were much broken and mixed together. The large bones, however, were well preserved, and in one skeleton the cervical and dorsal vertebrae formed a continuous series. It was unfortunately only possible to secure two heads, and these, though apparently entire, were so soft, fragile and broken that they had to be set immediately in a half mould of plaster of paris

The position of the bird remains were here, as elsewhere, indicated by the presence of circular surface patches of "gizzard-stones," consisting of coarse sand and small siliceous pebbles, not exceeding three-quarters of an inch in diameter, the surface of which were smooth and worn as if by attrition.

The stones comprised in one entire patch weigh fourteen ounces, and include examples of siliceous sandstone, jasper, claystone (blackened on the outside), black quartz, clear quartz, chalcedony, together with a few fragments of blue, brittle clay with worn edges. These stones are not now found on the Flinders Range, but are characteristic of the great Central Australian plain formation which extends from the Lake Eyre basin across the continent to the Gulf of Carpentaria,

Such pebbles occurred either scattered or in groups at various places in the Lake, and were the only stones of any kind to be found anywhere on its surface. The only shell found in the clay matrix of the bones was a minute fresh-water mollusc *(Potamopyrgus sp.),* Three fruits, however, of a Callitris, determined by Professor Tate to be *C. robusta,* a species now living, were found embedded in the same hlue clay, and some fructifications of *Chara* were washed out of it.

In addition to the above-mentioned forms there were collected a few small bones and fragments, both mammalian and avian, of species not yet determined.

FOOD REMAINS

Associated with the skeletons of Diprotodon, in a relative position which corresponded with that of the abdominal cavity, were occasionally found loosely aggregated globular masses of what were judged to be the leaves, stalks, and smaller twigs of some herbaceous or arboreal plants. The fragments are very uniform in length, thickness and character, rarely exceeding an inch in length or a line in thickness. They are solid, often irregularly branched, frequently retaining portions of the bark, and have their ends often frayed or crushed, as if by the action of teeth. Microscopic examination showed the structure of the sclerenchyma tissue to be well preserved, and gave clear indication of the existence of dotted ducts, but I could find no trace of leaves that might have suggested a diagnosis.* Judging from this entire absence of leaves and from the degree of maceration, or entire absence, of the bark, these masses probably represent the contents of the intestines. No traces of coprolites were, however, anywhere met with.

METEOROGICAL

Arriving at the camp on the 16th of August, the Museum party experienced fine weather, but very cold nights for about a week. Strong winds-mostly south-easterly, but veering in all directions, and increasing in strength for about twenty-four hours, and eventually subsiding-then became of frequent occurrence. Later on, towards the end of October, these gales, now usually, from northerly quarters, increased in force and frequency; beginning at any time in the day, and lasting twelve to eighteen, they carried dense clouds of the sand from the dunes and pulverized saline matter from the Lake, which were most irritating to the eyes.

In November these gales blew almost continuously and with still greater force, raising sandstorms so dense that it was impossible to see more than a few yards, and work was consequently impossible. Empty cases and even the bones laid out to dry were blown about the camp, sometimes to a distance of a hundred yards. The nights were intensely dark. Heavy clouds to the northwards often seemed to threaten for rain, but none came for some days. These clouds appeared to divide at the northern end of the Lake, to travel southwards on each side of it, and then to unite again. Mr. Ragless, at Callabonna, was convinced that in some way or another the Lake-bed was an obstacle which the rain-clouds from the west did not readily pass. During the day the heat was often intense, the thermometer in the tent rising frequently to 110° F., or not unfrequently even to 120°, but, the nights were still comparatively cool. Innumerable flies were in the daytime a constant and maddening source of annoyance to man and beast, and so tortured the camels that the margin of their eyelids became quite raw. About the middle of November there was heavy rain for eighteen hours, and a week later a severe sandstorm from the west, followed by a sharp thunder-shower, in which an inch fell in a quarter of an hour, and its impact on the surface of the Lake was so heavy that it could be heard at Callabonna Station, six miles distant. A fortnight later a second severe sandstorm from the west was followed by another heavy shower. Just previous to the latter rain large flocks of the Australian swift *(Cypselus australis),* locally called rainbirds, and considered to be a sure sign of heavy rain, passed over the Lake. On one night only was there a fog, which was of such peculiar denseness that the candle in the tent threw hardly any light, and its flame appeared surrounded by a yellow halo.

Previous to heavy weather immense numbers of nocturnal insects came round the camp fire at night, and a large collection of them was made.

---

* As mentioned elsewhere in these Memoirs (vol. I., p. 36), samples of these remains of food (or excrement) were, at the suggestion of the late Baron von Mueller, submitted to Professor Radlkofer, of Munich, who reported of them that they consisted of the stems and twigs of plants belonging chiefly to the order Salsolaceae, or to the allied orders Amarantaceae or Nyctagineae.

RABBITS

During November the camp became almost unbearable from the stench -produced by the dead carcasses of rabbits which had come to drink of the waters of a very brackish, in fact salt, spring at the base of the sandhill, about a hundred yards from camp. Round this they died after drinking, or else perished after crawling for shelter into the tents and empty boxes. It became part of the routine of the camp to bury upwards of fifty bodies every night, but still the nuisance was hardly lessened. The rabbits also caused many bones to be broken by crawling under them in search of the little pools of salt water which dripped from them as they were laid out to dry. In their frantic search for water they bit holes in the water-bags in camp and, on the mainland gnawed the stems and roots of the "needle-bush," a species of Hakea. In one night at Callabonna Mr. Ragless killed 1,400 with poisoned water, and what with drought and the ravages of these pests, which stripped the scanty bushes of every green leaf till they were nothing more than bundles of bare sticks, the surrounding country presented an appearance of desolation that defies description,

Under such circumstances of heat, sand and effluvia, it is not surprising that the health of the party suffered eventually from ophthalmia and gastro-intestinal complaints, and, indeed, it was chiefly this which led to the breaking up of the camp at the end of November for the time being.

CONCLUSION

It would be an unworthy omission if I finally omitted to acknowledge the cheerfulness and skill with which Mr. Zietz performed his duties under somewhat arduous and depressing circumstances; indeed, whatever satisfactory results may have been achieved by this expedition they are most chiefly due to his indefatigable zeal in the interests of paleontology and of the Museum, To him also I owe many of the facts related in this communication. To the Messrs. Ragless our best thanks are due for their kindness and hospitality to members of the party at various times, and for many necessary articles supplied, sometimes, I fear, at their own inconvenience. Our great obligation to the Government of South Australia for the loan of camels, granted through the mediation of the Surveyor-General, the late Mr, Goyder, I have already acknowledged.

For the preceding notes I can only claim that they comprise but a rough and imperfect epitome of the physical features of the fossiliferous area and of the conduct of the Museum party's operations. As has been already stated, until the whole of the specimens have been unpacked, cleaned, mended, examined, and compared no complete summary of the palaeontological results can be given. It must further be remembered that the South Australian Museum still suffers under the general retrenchment imposed upon all Government institutions by current financial exigencies, and this during a period when its limited staff-barely sufficient for routine work-is called upon to deal with, for it, an unprecedented mass of material, to say nothing of the fact that, within the same period, it has been also called upon to remove and rearrange the whole of its collections in a new and more commodious building. I mention these facts as a plea for some indulgence for the delay that must inevitably take place before the full scientific results can be made known.

With this expedition to Lake Callabonna must ever be associated the name of the late Sir Thomas Elder, G.C.M.G., a gentleman who was conspicuous amongst Australian colonists for the support he so frequently and so munificently displayed in the interests of education and exploration in his adopted country. Had it not been for a timely and generous contribution from him to the straightened funds of the Museum the exploration could only have been very inadequately carried out. Even as it is, much remains to be done, not only in this partially explored and promising bed of Lake Callabonna, but in many other localities. It is to be hoped, therefore, that the South Australian Mueum may be soon put in such a position that it may be able to resume its investigations in this direction. For the present, however, it can only be regretted that its exiguous means; renders any such undertakings quite impossible.

EXPLANATION OF PLATE A

Fig 1. View, looking south-west, showing part of the flat saline expanse of Lake Callabonna, with the western shore just visible as a dark streak. The elevation in the foreground is the top of the sand-dune at the foot of which, on the further side, somewhat to the right of the erect figure, the camp was situated. The vegetation is stubbly samphire *(Salicornia).* The bulk of the fossils were obtained on the flat to the (observer's) right of the erect figure on the sand-dune.

Fig 2. Surface skeleton of Diprotodon australis (*vide* p. x.).

Fig 3. Skeleton of Diprotodon australis in process of excavation. The right humerus is extended to the (observer's) left; a stick crosses, and is bound to, the pelvis, and the tail is seen resting on a white patch.

Fig 4. Head of Diprotodon australis, partially exposed, lying in the clay matrix.


1


2


3


4

Vol 1. Part 1

MEMOIRS
OF THE
ROYAL SOCIETY OF SOUTH AUSTRALIA.

FOSSIL REMAINS OF LAKE CALLABONNA.

Part 1

DESCRIPTION OF THE MANUS AND PES

OF

DIPROTODON AUSTRALIS, Owen.

by

E. C. Stirling. C.M.G., M.A., M.D., F.R.S, C.M.Z.S., Director
and
A.H.C. Zietz, F.I.S., C.M.Z.S., Assistant Director

SOUTH AUSTRALIAN MUSEUM

ADELAIDE:
W. C. RIGBY, 74, King William Street.
Parcels for transmission to the Royal Society of South Australia, from Europe and America, should be addressed "per W. C. Rigby, care Messrs. Thos. Meadows & Co., 35, Milk Street, Cheapside, London."

TABLE OF CONTENTS

DESCRIPTION

OF

THE BONES OF THE MANUS AND PES

OF

DIPROTODON AUSTRALIS, Owen.

By
E. C. Stirling, M.D., F.R.S., C.M.Z.S, Director,
and
A.H.C. Zietz, F.I.S., C.M.Z.S., Assistant Director South Australian Museum

Plates I - XVIII

[Read July 1899]

It must be a matter of regret that, through lack of opportunities, Sir Richard Owen, whose labours embodied in his "Researches on the Fossil Remains of the Extinct Mammals of Australia" have contributed so largely to our knowledge of the skeleton of Diprotodon, was not in a position to apply his vast experience to the elucidation of the structure of the feet of this great marsupial. The work referred to, it is true, contains descriptions and figures of three of the bones of the manus, but these appear to be all that had come under his notice; and it is scarcely surprising that, with material so limited at his disposal, the author should have entirely mistaken the nature of one of them. References to a few other bones of the feet occur in the British Museum Catalogue of Fossil Mammalia, Part V., [1887] (Lydekker), but, so far as we are aware, no detailed accounts of any others than those described by Owen have appeared, and it is certain that all the material hitherto available has been quite insufficient to permit of adequate description of either member in anything like its integrity.

Indeed, it is singular that, amongst the very numerous remains of Diprotodon which have been found so widely spread throughout Australia, bones of the feet have been of comparatively infrequent occurrence, and the relatively few of these that have been discovered have, we believe, usually been met with singly or, at least, in number and variety insufficient for reconstructive purposes.* Thus we have so far lacked the assistance that a knowledge of the constitution of the feet of Diprotodon might have given us in determining its affinities.

The large deposit of fossil bones discovered in the bed of Lake Callabonna, South Australia, having, however, yielded more ample and complete material in this respect than has hitherto existed, we are now enabled to submit a reconstruction of both manus and pes, together with descriptions of all the constituent bones; but, before proceeding to this, a few remarks seem both desirable and, under the circumstances, necessary.

A preliminary account of the general features of the Callabonna discovery appeared in "Nature" (Vol. L., 1894, pp. 184 and 206). Subsequently, in two papers published in the Transactions of the Royal Society of South Australia (vol. XX., 1896, pp. 171 and 191), some account was given of a large struthious bird *(Genyornis newtoni),* the remains of which were found associated with those of Diprotodon and other marsupials.

From various causes, which we regret but for which we are not responsible, it has not been practicable for us to publish further details of this discovery. Very recently, however, the liberality of the South Australian Government has removed one principal obstacle to progress in this direction by a special grant of money, which, under the auspices of the Royal Society of South Australia, is to be devoted to further publications dealing with these remains. We therefore gladly take this opportunity of acknowledging, gratefully, this timely assistance of the Government, exercised through its Treasurer, the Hon. F. W. Holder; and we hope that this contribution will be followed by others on the same subject.

Though much still remains to be done before the large mass of material-the condition of which presented exceptional difficulties in the way of preparation-can be fully turned to account, yet sufficient progress has been made with the work to enable it to be seen that the Callabonna remains almost certainly comprise two good species of Diprotodon, and possibly a third.

The largest form, whose bones constitute the great bulk of the material obtained, is undoubtedly referable to *Diprotodon australis,* Owen. Species approximating to this in size, but somewhat smaller and less massive, have been founded by Owen, doubtfully, as *D. bennettii,#* and by McCoy as *D. longiceps.||* So far as the latter is concerned, we can state now that, while some of the Callabonna fossils certainly reveal the dental features on which the author has based his determination, we believe that we shall be able hereafter to show that the characters in question do not amount to more than variations, which arc to DE o bserved within the limits of Owen's original species.

---

* It may be, perhaps, worth mentioning that the few odd bones, of the pes exclusively, which had come into the possession of the Museum previous to the Callabonna discovery were all from northerly regions situated not a great distance from that locality. Amongst a considerable number of excellently preserved fossil fragments-chiefly those of Diprotodon, but also of Phascolomys, Thylacoleo and of some of the Macropodidae-which have been, from time to time, received from a district to the South of Adelaide (Normanville)-there has not been a single specimen of the bones of either manus or pes of any of the animals mentioned. The fact of these relatively small bones having been found at Callabonna so numerously and in aggregates is, of course, part of the evidence indicating that these animals have here perished *in situ* (see" Nature," Vol. L., 1894, pp. 185 and 208).

Extinct Mammals of Australia, pp. 510-511 (Text).

||Prodromus of the Paleontology of Victoria, Decade IV., pp. 7-11.

The somewhat doubtfully expressed diagnosis of *D. bennettii* as a distinct species was based upon a portion of a mandible which differed in shape and proportion from that of *D. australis,* and we perceive that certain differences of this character do certainly exist amongst the Callabonna specimens. We are, however, not yet in a position to express an opinion as to the specific value or otherwise of the characters believed to distinguish the species in question.

Remains fairly numerous and various, though much less so than those of *Diprotodon australis,* indicate the former existence of an undoubted Diprotodon of smaller size and more slender build, the length dimensions of whose long bones are about three-quarters, while latitudinally they are about two-thirds, of the corresponding dimensions of the larger form. This may be referred provisionally, and we are inclined to think definitely, to *Diprotodon minor,* Huxley*, with the size of which, under the very limited comparison possible, it appears to accord. There is not, it is true, absolute similarity between the premolar on which the determination of Huxley's species is chiefly based and that of the Callabonna fossils, but as we find intermediate characters existing in the homologous premolar of a small Diprotodon from another part of South Australia, and as the features of the comparable true molars are almost exactly similar, we are inclined to regard the small forms, both from Callabonna and elsewhere in South Australia, as identical with Huxley's species.

The correctness of Huxley's diagnosis in assigning his fragment to the genus Diprotodon has been questioned by Owen, who ascribed it to a species of Nototherium#. From what has appeared, however, we can have little doubt of the accuracy of the judgment of the former author, and this opinion has also been expressed by de Vis||.

As to the fact of the existence of a relatively small-sized Diprotodon there can be no doubt whatever, as evidenced by its numerous remains in our possession from Callabonna and elsewhere; the point on which the limited comparison possible does not permit us to be absolutely certain is its specific identity with Huxley's species.

So far as a critical comparison has been made between this small species and *D. australis,* the difference between the two seems to be mainly one of size, all the comparable bones of the latter very closely reproducing, on a diminished scale, the features of those of its larger ally; and this difference of bulk appears to be too great to be explicable on the basis of sexual character, although this possibility is not lightly to be dismissed when the great preponderance in size of the males of some of the Macropodidae over that of the females is borne in mind.

• Quarterly Journal of the Geological Society, vol. XVIII. (1862), pp. 422-427.

#Extinct Mammals of Australia, p. 511 *(Text).* Two contiguous teeth-the premolar and first molar-belonging to the fragment in which *D. minor* was founded seem to have been refigured by Owen, who ascribed them to *Nototherium inerme.* (Compare fig. 4, pl. XXI., of Huxley's paper with fig. 15, pl. LXXXVIII., Extinct Mammals of Australia.) The two homologous teeth, doubtfully referred by Huxley in the same paper to *D. australis*, also appear to have been refigured in *Owen's* work, where they are referred to *Nototherium mitchelli.* (Compare figs. 1 and 2 with figs. 11 and 12 of the same two plates respectively.) It should; perhaps, be stated that in making this comparison we have only been able to refer to the plates. The resemblance between the two sets of figures is, however, unmistakable.

||Proc. R. Soc. of Queensland, vol. V. (1888), part 2, pp. 38-44.

It is just possible that a further examination of the Callabonna specimens may reveal a third species of a size somewhat larger than *D. minor*, but inferior to *D. australis*, for we find that certain of the lower jaws differ considerably in contour and proportion from those which we assign to the former species. Bearing in mind, however, the similar differences which exist amongst the mandibles of larger size, and the uncertainty concerning their significance, we prefer not to discuss this point until we shall have been able to make a more thorough examination. This may also, perhaps, enable us to eliminate the difficulties, as yet undetermined, which are connected with the question of sexual differences.

As found, *in situ* in the lake bed, the feet of the Diprotodons, lying at a depth of from three to four feet, formed the .most deeply situated parts of the skeleton. At this depth the salt clay in which the bones were embedded was always wet, and the necessary excavations soon became filled with water by drainage from the surrounding ground. For this reason it was necessary to remove the feet *en masse*, leaving them contained within large balls of the matrix-clay. Of these fourteen were obtained. An attempt was made in camp to remove and prepare the bones but, as all such work had to be conducted in the open air and during the boisterous weather which prevailed throughout the greater part of the period of operations, to say nothing of the flying particles of salt and drift sand, and of the attacks of myriads of sand-flies, this attempt at restoration on the field had to be abandoned and the work left until it could be more conveniently undertaken under the shelter and with the better appliances of the Museum. When this was done the clay was easily removed by placing a ball containing a foot upon a small-meshed sieve, and directing upon it a stream of water, at low pressure, through a hose fitted with a fine nozzle. The bones being thus left upon the sieve were then dried, mended and hardened. Care was, of course, taken to keep separate all the bones contained in each clay ball, and they were afterwards arranged as nearly as possible in the positions in which they were found. When these positions were clearly natural, the bones were marked accordingly.

The differences in the number and condition of the bones in the various balls was rather remarkable. While some of them contained a more or less complete series, in others all, or nearly all, of the original contents had crumbled into a mass of minute fragments, and it was usually found that, in this respect, the hind-feet were in worse condition than the fore; no single specimen of either proved to be perfect throughout, and thus, for reconstruction, it became necessary-as will be afterwards mentioned more particularly-to use bones of more than one specimen.

Besides the contents of the clay balls, many odd specimens of bones, both of the manus and pes-most frequently those of the digits-were found disseminated throughout the clay in the field of operations; all of these were, of course, carefully collected.

As regards the actual condition of the feet bones, the phalanges (if at all they had preserved their integrity) were usually in a better state of preservation than any others of the Diprotodon remains. The state of the carpals, metacarpals, tarsals and metatarsals, though not so satisfactory, was yet better than that of the long and flat bones, the former being to some extent, and the latter greatly, affected by saline infiltrations, as described in speaking of the condition of the bones of Genyornis*.

As it may explain some of the difficulties that have been experienced in the preparation of the Callabonna fossils, we may take this opportunity of saying a word as to the Diprotodon skulls, the condition of which, in particular, has given rise tu the greatest amount of trouble and anxiety. As found, *in situ* most of these appeared to be complete, although often more or less crushed and distorted in one or other direction, according to the position in ,which they were lying. They, as well as other bones. were largely impregnated with fine clay which, on drying, became exceedingly brittle. Some bones of the skull, such as the parietal, occipital and palatal, and some of those of the face, are exceedingly thin for the cranium of so large an animal, and these were consequently very fragile. Such parts were generally found broken up into small fragments, which lay like a mosaic upon the clay that completely filled all the cavities. When a skull was to be removed, the surrounding clay, except that immediately beneath which was left as a support, was first cleared away from it. Drainage from the skull-mass being thus permitted, it was afterwards removed to higher ground for further treatment with glue or isinglass and, even when dried and prepared, these masses weighed close upon two hundredweights. Although the greatest care was taken, it generally happened that the skull broke when the mass was lifted, the facial bones being particularly liable to separate from the brain-case. Several skulls, thus treated with glue and wrapped in strips of calico soaked in the same material, subsequently proved to be valueless when examined in Adelaide; though their glue coatings were intact, the entire contents, with the exception of a few larger pieces of the jaws, had crumbled into a worthless mass of minute fragments. No doubt a great amount of breakage, to which all the skulls have been subjected, more or less, was due to the inevitable accidents of camel transport for a distance of nearly 200 miles to the nearest railway station. This, of course, involved repeated loading and unloading, which operation, especially the latter, were naturally very liable to cause jarring of the brittle contents of heavy cases. Even at the very start upon the journey several of the camels got bogged to their bellies in crossing the strip of lake surface which intervened between the working camp and the nearest solid land, and, under such circumstances, leisurely care, in the unloading which was necessary in order to extricate the animals, was scarcely to be expected. It was unfortunate, too, that a consignment of suitable packing material ordered did not reach the camp, and that which was actually available on the spot was both inadequate in quantity and quite unsuitable for the purpose.

On overlooking the whole collection, great inequality is found to exist in the number obtained of the various bones of the feet. Some of them, such as the scaphoid, pisiform, unciform, trapezium, trapezoid, the metacarpals (except the fifth) and the phalanges of the manus, together with the astragalus, calcaneum, cuboid and the fourth and fifth metatarsals, are numerously represented. Of those of which we possess comparatively few examples are the phalanges of the pes and the second and third metatarsals, doubtless by reason of their

---

*Trans. R. Soc of South Australia vol XX. (1896)

diminutive size. It is singular that while we have a good many of the large fifth metatarsal, the very similar corresponding metacarpal is very scantily represented.

THE MANUS

For reasons which have been elsewhere explained, it was, unfortunately, not found possible to restore any single specimen of the manus in its entirety. In the member figured as a whole in half-size, on plate l., a natural set of phalanges from one fore-foot has been combined with a set of carpals and metacarpals from another, similarly homogeneous except as to the cuneiform which, alone amongst them, was so imperfect as to be useless for the purpose. Care has however, of course, been taken to adapt the two sets in respect of size. Unfortunately, the cuneiform, which our very limited choice of right-sided bones compelled us to select for the articulated foot, is not as good a fit as could be wished. The carpal bones chosen for individual illustration, in subsequent plates, were so selected primarily on account of their typical characters and of the excellence of their state of preservation, and in pursuance of the belief that there would be a certain convenience in representing them all as belonging to one and the same side-and that the same as in the mounted foot-this has been done. It should, however, be stated that the scaphoid, unciform, and pisiform so figured were, in reality, left bones which have been reversed in the process of reproduction in order that they might correspond with their fellows, all of which do actually belong to the right side. Right-sided bones throughout could, of course, have been selected, but the superiority in condition of the left bones mentioned rendered them preferable both for representation and description. As the metacarpals and phalanges were known to be a perfectly homogeneous series, and were in as satisfactory a condition as any others in the collection, there was no advantage to be gained by breaking up the set, and it is these that have again been figured, in subsequent plates, on the scale of natural size.

SCAPHOID.

Pl. II., figs. 1--4.

This bone, correctly referred by Owen to the carpus of *Diprotodon australis* and apparently the only one of the carpal series that had come under his notice, has been figured and briefly described by him as the scapholunar*. For the purposes of this description we shall adopt the view, supported by Flower, that it here represents the scaphoid only,# the lunar being suppressed.

As, so far as we know, no complete description of the radius and ulna has appeared, it may be as well to state preliminarily that, in *Diprotodon,* the former bone completely crosses in front of the latter-a fact, indeed, which is clearly shown in Owen's figure of the restored skeleton,|| though, of the two bones in question, his description extends only to the proximal half of the ulna. Thus, in the ordinary quadrupedal position, the lower end of the radius lies

* Extinct Mammals of Australia, p. 507 *(Text);* pI. cxxii., figs. 1-3.
#Osteology of the Mammals
||Foss. Mam., pl. xxxv.

to the inside of that of its fellow, and the radial side of the manus is consequently internal, while the ulnar side is external, in position. We may also add, as we believe the fact has not been noticed, that the characters of the superior radio-ulnar articulation, in which an almost perfectly circular and cupped head is received into a semicircular "lesser sigmoid" concavity, are such as would, in themselves, permit of some amount of change from the prone towards the supine position.

The scaphoid shows a somewhat conspicuous division into two moieties-an outer part, corresponding to the ulnar side, which is almost wholly occupied by articular surfaces, and an inner, or radial, which is largely, but not exclusively, non-articular. These two moieties are delimited by a more or less well marked, obliquely circumferential, but not wholly continuous, furrow (pl. II., figs. 1-4 A A). This, on the proximal or superior aspect,* defines the radial articular surface (figs. 1, 3 and 4 B), which is ovo-pyriform in outline and generally convex, the convexity being greater in the transverse than in the longitudinal axis of the bone. Anteriorly its margin is produced into a conspicuous obtusely angular process (figs. 1-3 c), to the extreme tip of which, however, the smooth radial articular surface does not usually reach. Internally to the furrow, which has just been mentioned, the proximal surface is, with the exception of a small facet for the tip of the styloid process of the radius (figs. 3 D), non-articular, rough and perforated by numerous vascular foramina. [In fig. 1 the situation of this small facet is indicated by the same letter, though its character can scarcely be distinguished.] This radial styloid facet varies considerably in size, shape and distinctness and is, in some cases, uninterruptedly continuous with the main radial convexity; in others the groove (A A) separates the two from one another. In several bones it is non-existent as a distant articular tract.

Internally the bone terminates in a smooth, rounded convexity, of which a part (figs. 1 and 3 E)-seen best from the proximal aspect, but also from the anterior-supports a large sesamoid bone; while contiguous to this, but anterior and inferior, is a small often ill-defined, facet (pI. II., fig. 3 F), with which articulates the trapezium. The sesamoid in question (pI. II., figs. 5 and 6) is a concavo-convex, lens-shaped ossicle, of which further description is unnecessary. A comparable ossicle is found in the manus of *Macropus,* but in this case it is applied to the trapezium, and is rather more externally situated.

The inferior surface (pI. II., fig. 2), like the superior, presents an external, wholly articular, and an internal, mainly non-articular, part. The former comprises the contiguous,

• In view of the variety of terms that have been suggested as descriptive of position, it may, perhaps, conduce to accuracy if the exact meaning that will be attached to each of those used in this paper is stated. Proximal and distal will be used in their accepted sense as referring to those surfaces which can be referred to as nearest to or furthest from their organic base of attachment,. and the adverbial derivatives of those terms, proximad and distad, to parts relatively nearer to or more remote from such base of attachment of any structure. Anterior and posterior, internal and external, will imply relative position in regard to the fore and aft axis, and the fore and aft median vertical plane respectively. Superior and inferior indicate relative levels in respect to the horizontal plane of the plantigrade foot, and these terms will thus generally correspond to dorsal and palmar or plantar, which expressions have reference to the dorsum and sole. Similarly, dorsad and palmad or plantad will imply relative position thereto. Radiad and ulnad, tibiad and fibulad, will imply direction towards the sides on which the bones indicated lie in their actual position in the limb, and not always separately defined, articular surfaces for the unciform (fig. 2 G), magnum (H), and trapezoid (I), the first-named and most externally situated being semi-circular and flat, the second elongated and slightly concave, and the third semi-oval or crescentic, concavo-convex and extending on to the under surface of the angular process (C), into which the anterior margin has been described as being produced. The remainder, or internal portion, of the distal surface is transversely convex, rough and tuberous; but near its extremity, and situated somewhat anteriorly, it bears the small and often indistinct facet that has been mentioned as forming, with that for the trapezium, a smooth, rounded internal end for the bone.

The posterior surface (fig. 4) is non-articular, except for that portion of the radial convexity (B) which encroaches on this aspect. The posterior limits of the latter are defined by the furrow (A A), which is here very distinct and oblique. The non-articular part, lying inferiorly and internally to the furrow, is traversed by a broad, shallow trough or depression (J),* on each side of which the surface is rough and tuberous.

As the scaphoid was collected in greater numbers than any other member of the carpus, and was generally in excellent condition, it may be used as an index of dimensional variation. Out of 40 bones sufficiently perfect to allow of accurate measurement (from the radial to the ulnar end), the longest-the bone figured-is 122 mm., the shortest 99 mm., and the mean length 108 mm.

CUNEIFORM.

Pl. III., figs. 1-3.

This bone has the general shape of a short and broad wedge with its base directed externally. The wedge-like characters however are best defined at the dorsal end (pI. III., fig. 3). Its proximal surface (fig. 1) exhibits a well-marked oval, pyriform or circular, uniform concavity (figs. 1 and 3 A) which provides about one-third of the cup for the globular head of the ulna. This occupies the anterior half to two-thirds of the proximal surface; inferiorly and posteriorly to this and demarcated by the raised rim of the concavity is a, generally, much smaller facet for the pisiform (fig. 1 B). This however is very variable in size and shape, being in some cases as large as the ulnar concavity in others, as in the bone figured, barely a quarter of its size. It may be flat or very slightly concave.

Of the distal, or antero-internal, face of the bone (fig. 2) the whole breadth of the dorsal, or superior, half is occupied by a sub-circular articular facet (c) for the unciform. This is nearly flat or only very slightly concave. Palmar wards of this facet the surface is non-articular and rough.

The external surface forming the base of the wedge to which the shape of the bone has been likened is entirely non-articular, tubero-striated and beset with vascular pores. Similar characters extend to the dorsal surface (fig. 3 E).

---

*This is not very clearly shown in the figure

The internal surface, corresponding to the edge of the wedge is represented dorsally for a short distance by the thin border (fig. 3, D) at which the ulnar and unciform facets meet one another at an acute angle. Palmad of this line of meeting the respective borders of the two facets gradually diverge and the surface broadens into a wider but, when compared with the base of the wedge, a relatively narrower rugose tract.

PISIFORM.

Pl. III., figs. 4 and 5; pI. IV., figs. 1 and 2.

This bone, by far the largest of the carpal series, is that which was described by Owen as an ungual phalanx*. Situated completely to the rear of the rest of the carpus its position enables it adequately to serve the mechanical purposes of the fulcral portion of the calcaneum to which bone of the pes, indeed, it bears a remarkable resemblance both in size and shape.

On its anterior face (pI. III.; fig. 4) this massive bone exhibits a large, transversely oval concavity (A) which forms the posterior portion of the ulnar cup to the extent of rather more than one-half of its area. The vertical depth of this concavity is co-extensive with that of the anterior face and on its outer side it is bounded by a somewhat narrow prominent border (B); on the inner by an equally prominent but broader, and generally roughened, tract (0) of which the inner margin runs concentrically with that of the corresponding edge of the concavity. In some examples this tract appears wholly non-articular in character but in others the inferior part of it shows a definitely flattened or even slightly concave and smooth facet (D) which encroaches towards, or on to, the palmar surface. Against this, in the articulated foot, rests, if it does not directly articulate with it, a part of the unciform that will be described in this relation *(vide* remark in explanation of pl. I.).

At the anterior and outer corner of the palmar surface (pI. IV., fig. 1) is a semicircular, oval or subcircular and nearly flat facet for the cuneiform (pI. III., fig. 4 ; pl. IV., fig. 1 E) of which the anterior edge is conterminous with the inferior lip of the ulnar concavity. The remainder of the palmar surface shows, in different bones, considerable variations of the sculpture. Most commonly a very tuberous or roughened ridge or less regular elevation (F, F) is found crossing the bone transversely in a curved line about an inch to the rearward of the ulnar concavity. This is not unfrequently cleft either about its middle or towards one end by an antero-posterior channel which varies from a wide groove to a narrow fissure (pl. IV., fig. 1, between F and F). In other instances the elevation is uninterrupted but in nearly all cases the front face of the ridge *is* steep or even undermined while posteriorly *it* subsides gently into the general surface. Exclusive of the cuneiform facet the tract of bone between this ridge and the lip of the ulnar concavity is flat, undulating, concave or depressed into a deep pit. Posterior to the ridge the palmar surface is more or less flat or gently undulating and is generally marked by small elevations and depressions and by the orifices of vascular canals.

---

*Extinct Mammals of Australia p 508 (Text) Pl CXXIII

On the dorsal aspect (pl. III., fig. 5) the anterior border, forming the superior margin of the ulnar concavity, is elevated into more or less of a ridge which is succeeded posteriorly by a slight corresponding depression. About the centre of this aspect is a gently rounded and generally smooth elevation (fig. 5 G). This, as well as the remainder of the dorsal surface, is beset with very numerous vascular openings.

The internal surface is rather characteristically saddle shaped, its posterior border being much wider vertically than the anterior and forming, with the tract lying internally to the ulnar concavity, a broadly rounded roughened eminence which may be likened to the cantle, while the pummel is represented by a posterior elevation of less prominence and vertical width (pl. III., fig. 5 and pl. IV., fig. 1 H, I).

The external surface, of less extent antero-posteriorly, also shows two prominences which are less conspicuous and more closely approximated than those on the aspect just described. Of these the anterior (pl. III., fig. 5 and pl. IV., fig. :4 J), more ridge-like in character, supports the outer lip of the ulnar concavity, while the posterior (K) is more irregular and more roughly tuberculated. Sometimes the intervening depression is so inconsiderable that the two elevations may be almost confluent *(vide* pI. III., fig. 5, where these two elevations are shown in perspective). In one of Owen's figures* the more posterior of the two is shown as of exceptional prominence.

The posterior surface is limited to a relatively narrow tract which intervenes between the two corrugated borders (pl. IV., fig. 2 L Land M M) which usually bound posteriorly and, to some extent, internally the dorsal and palmar surfaces. Thi's tract generally displays, as Owen has figured, the features of a marginal groove but not unfrequently the groove is absent, in which case the tract assumes the form of a very roug-hly tuberculated rounded border.

TRAPEZIUM.

Pl. IV., figs. 3-6.

This bone, irregular in form but exhibiting a definite median constriction and two somewhat expanded extremities, has, when *in situ,* its longer axis placed transversely to that of the manus. At its external end, which is directed almost directly backwards but also a little outwards, is an oval, slightly convex facet for articulation with the trapezoid (pl. IV., figs. 3, 4, and 5 A).

The proximal surface (fig. 4) bears at its inner part a small and, usually not vyery well defined tract (between B and C) which abuts against the similarly ill-defined facet (F) that has been described as existing at the inner end of the scaphoid contiguous to that for the sesamoid ossicle. Both of these facets, in fact, so frequently lack in the smoothness and definition characteristic of articular surfaces that they may be easily overlooked, and this indistinctness obtains to a considerable extent in the bone figured though its outline has been artificially defined by a faint, circumscribed pencil mark. In some cases, however, its articular features are quit,)

---

*Extinct Mammals of Australia Pl CXXIII fig. 1

distinct and it then takes the form of a definite, sub-circular or oval facet. The remainder of the proximal surface, viz., that lying between the edge of the trapezoidal facet and of that for the scaphoid, which region corresponds to the constricted waist of the trapezium, does not touch the scaphoid, but the bones are here separated by a distinct space.

The dorsal surface (fig. 5) is, towards its inner border, raised into a prominent, rough and somewhat antero-posteriorly compressed tuberosity, on to the posterior surface of which the scaphoidal facet extends (figs, 3, 4, 5, 6 0), while on the palmar aspect the bone is rough and uneven.

The articular features of the distal surface (fig. 6) are variable; some examples of the bone show, on the outer half, a single sub-circular, flat facet (figs 5, 6, D) for the pollicial metacarpal; others a second, though usually less definite, facet on the inner half, while sometimes the two are united into a continuous, elongated articular tract which is nearly coextensive with the transverse width of this face.

The inner end of the bone forms a rough non-articular convexity, which requires no special description.

TRAPEZOID.

PI. V., figs. 1-4.

This bone, much the smallest of the carpal series, is wedged in between the scaphoid, magnum, trapezium and second metacarpal with all of which it articulates (pl. I., TD). Its form may conveniently be described as approximating to that of a trilateral pyramid* with an oval base (figs. 2 and 3 D) which forms the articular surface for the trapezium, while the apex is wedged in the angle between the scaphoid and magnum. To the former it articulates by a nearly flat, or gently undulating, facet (fig. 1 A) which occupies the dorsal half, two thirds or, in some cases, nearly the whole of this (the postero-internal) surface.

The opposing or antero-external face (fig. 2) combines in one continuous articular tract the facets for the magnum (B) and for the inner side of the wedge-shaped end of the second metacarpal (0). These sometimes lie in one plane in which case the dorsal contour is trilateral, as in pI. I., TD, but more often their planes make an angle with one another which feature is sometimes sufficiently marked to confer upon the dorsal surface, as in fig. 4, a distinctly quadrilateral instead of a trilateral outline.

The anterior aspect, which is at the same time somewhat inwardly directed, articulates with the trapezium by a well marked oval or pyriform concavity (figs. and 3 D). Dorsally (fig. 4 E; also figs. 1 D, 2 and 3 E) the bone presents a moderately rough, non-articular convex surface the varying character of whose outline has been explained.

---

* *Vide infra* for explanation of the quadrilateral form of the dorsal surface shown in pl. *V.,* fig. 4. It can be seen that this contour would be converted into a trilateral figure by the obliteration of the angle between G and H.

OS MAGNUM.

Pl. V., figs. 5-8.

The proximal surface of this bone (pI. V., figs. 5, 7 A A), by which it articulates with the scaphoid, is so much inclined towards the inner side of the manus that it will be simpler to describe it as part of the internal surface of which it appears to form part. This, then, the internal surface (fig. 7) presents an elongated, curved, undulating articular tract (fig. 7 B, A, A), which occupies rather less than the dorsal half of its extent, Of this tract the posterior two-thirds (A, A) is that which articulates with the scaphoid and is so inclined that it meets the external surface at an acute angle, thus forming, with the latter, a sharp edge *(vide* fig. 5 to the left of A A) which is contiguous to, and is received within, the concavity of, the crescentic scaphoidal surface of the unciform. At the same time that part of the magnum which is presented to the scaphoid has usually sufficient convexity to produce a corresponding concavity on the surface of the latter bone while, on the other hand, the adjoining tract (of the scaphoid) for the unciform is invariably quite flat *(vide* pI. II., fig. 2 G and H).

The remainder (pl. V., fig. 7 B), or anterior third of this articular area, lying in a somewhat different plane to that of the scaphoidal moiety but uninterruptedly continuous with it has abutting against it the posterior part of the antero-external tract of the trapezoid. The general disposition of these two tracts of the magnum-scaphoidal and trapezoidal-is such that they may not inaccurately be described as continuous parts of a very open spiral surface.

Palmad of these confluent articular tracts the surface of the bone is depressed while the palmar border itself forms a low, rough ridge (fig. 7 c).

On the external surface (fig. 8) a continuous articular tract (D, F, E) follows the sweep of its dorsal and posterior borders thus forming a curved or angulated facet, the whole of ·which adapts itself to a corresponding tract on the inner face of the unciform with such precision that the two bones may be almost said to interlock. It is with the posterior and inferior part of this facet (fig. 8 F to E) that the scaphoidal tract on the inner surface forms, as has been mentioned, the sharp edge that is received within the concavity of the crescentic scaphoidal surface of the unciform. Palmad of the articular tract the external surface is non-articular and more or less depressed though to a less extent than on the inner surface.

The distal surface (fig. 6) is transversely constricted at its middle, and the width, in that direction, of the dorsal border is greater than that of the palmar. For the greater part of its extent (G, G, G, G) the distal surface bears the base of the mid-metacarpal, but the anterointernal vertical edge of the bone is, so to speak, bevelled off, thus forming a narrow and elongated vertical facet (H to H) with which articulates the truncated edge of the wedge shaped end of the second metacarpal. Or, sometimes, as in the bone figured this facet is not continuous for the whole dorso-palmar depth of the bone but is restricted to two small discontinuous facets (at H and H) situated at the superior and inferior ends of the tract. In such cases direct contact between the magnum and the metacarpal is wanting at the intervening part.

The dorsal surface (fig. 5 I) consists of a limited sub-triangular flat, or slightly convex and rough, non-articular area which, on the dorsum of the foot, is seen to be interposed between the dorsal borders of its trapezoidal facet and of the anterior part of that for the unciform. The outer side of this surface, moreover, IS received into a corresponding indentation of the latter bone (pI. I.).

UNCIFORM.

PI. VI.

The proximal surface (fig. 1) is exclusively occupied by a crescentic, or sometimes more nearly semicircular, flat facet (A) for the scaphoid the plane of which is directed upwards, backwards, and inwards.

The external or, more accurately speaking, the postero-external surface (fig. 2) bears, conterminously and coextensively with the length of its dorsal margin, a broad and elongated oval facet (B) which is distinctly, though slightly, concave in its longer, and flat in its shorter, axis. This, on approaching the crescentic scaphoidal surface (A), sweeps palmar wards following the contour of its convex border, as a narrower articular tract and ends (at c) well on the palmar aspect of the bone. Of this continuous curved or angular facet the anterior two thirds of the superior arm (B) supports the cuneiform; the remainder, which corresponds to the angle of deflection palmarwards, together with the dorsal half of the inferior or descending arm, contributes to the formation of the ulnar cup, while the most inferior part of the same descending arm, or that portion of it which encroaches on the palmar surface, of which the articular characters are often less well marked than the remainder, has abutting against it the pisiform.

In the articulated fore-foot, of which plate I. is a representation, the cuneiform is a substituted bone and does not exactly fit its position*; thus it happens that the plsiform, being thrown a little out of its proper position, does not show actual contact with the unciform. The remainder of the postero-external surface is non-articular and usually exhibits an elongated depression or groove (D) lying palmad of the tract for the cuneiform.

By its antero-internal surface (fig. 4) the unciform articulates with the magnum by a triangular facet (E, F, E) of which the two sides correspond with the dorsal border and the concave margin of the crescentic scaphoidal tract respectively, while the base of the triangle crosses the bone diagonally. In not a few cases, two tracts conterminous with the abovementioned borders, meet one another at an obtuse angle and form an angulated, instead of a triangular, figure. In either case the whole tract is 'either uniformly concave along the line that has been described as the base of the triangle, or it is undulating comprising two surfaces, each concave in the direction of the sides of the triangle, with an intervening convexity at their point of meeting (fig. 4 F). The remainder of this surface is non-articular

*We possess very few right cuneiforms, so that our choice was limited.

and displays, just palmad of the base of the triangular articular facet, a circumscribed depression with a roughened plantar border.

When the magnum is applied to this bone though, as has been stated, the opposed articular surfaces fit into one another with great precision yet, from the fact that when the two are in position the non-articular depressed portions are then brought opposite to one another, there exists, in this region, a considerable space between the two bones.

The distal surface (fig. 3*), which is much wider transversely as well as deeper dorso-ventrally than the proximal, supports the fifth and fourth metacarpal, by an extensive and continuous area which occupies all but the lower third or fourth of its extent. A vertical groove which may be strongly marked or quite insignificant marks the division between the areas proper to the two metacarpals, the width of that for the fifth (G) being deeper vertically and from twice to thrice the transverse width of that for the fourth (H).# A more or less roughened ridge forms the palmar border of the distal surface of this bone and between this and the articular tract there is often a transverse groove.

The dorsal surface (pI. I., u) is flat or very gently undulating and is beset with small vascular foramina; while the palmar aspect (pI. VI, fig. 3 K) is prominently convex and, for the most part, highly rugose though it includes, at its posterior region, an extension of the articular tract on the postero-external surface of the bone that has been described as serving for a point of contact with the pisiform. No indication exists of such an unciform process as is found in *Macropus, Phascolomys* and *Phalangista.* The small bony excrescence seen on the palmar surface in fig. 4 is exceptional.

METACARPALS.

Pls. VII., VIII., IX.

M. 1 ||. A depressed sub-quadrilateral bone approximately as broad as long and more nearly resembling the proximal phalanges than the other metacarpals. The dorsal surface (pI. VII. 1.) is flat or slightly convex while the palmar is concave antero-posteriorly. The inner border is generally more protuberant than the outer which is nearly straight; the protuberance is sometimes conspicuous and not unfrequently, as in the bone figured, the border is produced into a very definite tuberosity (pls. VII. and VIIL, 1. T), in which case the breadth of the bone may exceed the length.

The proximal aspect (pI. IX.) presents such variations as might be expected from what has been said of the disposition of the metacarpal articular tract of the trapezium. Usually there is a sub circular, or oval, facet (pI. IX., 1., A) situated chiefly on the outer half; this

---

* In fig. 3 a considerable portion of the palmar surface is shown in addition to the distal; consequently the vertical height appears greater than it should be. The letter I marks the true limit of the distal aspect.

In the bone from which fig. 3 was taken this line of demarcation, being very ill marked, has been accentuated by a faint vertical pencil mark drawn on the bone itself.

||For the sake of brevity in the descriptive text M. will stand for metacarpal, while its ordinal rank will be indicated by a collocated Roman numeral. Thus M. 1. will signify the first or innermost bone of that series, and so on. Similarly, in the digits, Ph. will stand for phalanx, the ordinal rank of the digit will be indicated by a Roman numeral, and the number of the phalangeal segment by an ordinary figure. Thus the expression Ph. V. 1 will indicate the first or proximal phalanx of the fifth or outer digit; Ph. V. 2 the second segment of the same digit, and so on.

may, however, encroach upon the inner or, it may be, that the whole proximal face is articular. In nearly all cases the plane of the facet is slightly oblique by encroachment upon the dorsal surface (pI. VIIL, T.). Of the distal articular surface, which shares in the depression characteristic of the bone, the form is that of a hemicylinder with its long axis placed transversely.

In a considerable number of these (first) metacarpals, as in the bone figured (pI. VII.), a large nutrient foramen is conspicuous at or about the centre of its dorsal surface, and numerous other smaller openings occur both on this and on the ventral surface.

M. II. This bone, unlike *M. I.*, has the general characters of a metacarpal and is about twice as long as it is wide. Its distinctive features are the wedge shaped form of its proximal end, the production, palmad, of its proximo-inferior angle by which considerable vertical depth is conferred upon the base, and a prominent tuberosity on its dorsal surface.

The proximal end bears a vertically elongate facet (pI. IX., B B) for the magnum of which the plane is usually obliquely disposed to the longitudinal vertical plane of the bone; by this feature it encroaches somewhat upon, and usually appears to form part of, the outer surface of the base. Occasionally, as in the bone figured in pI. IX., an intervening nonarticular tract (between B and B) divides this facet into an upper and a lower portion.

The internal surface, vertically wide in the region of the base but much narrower distally, presents, contiguous to, and distad of, that just described, a flat or slightly concave, semicircular or gibbous facet for the trapezoid (pls. VIII., IT., and pl. IX. c). Immediately distad of this, again, the surface is raised into more or less of a tuberosity (v) the summit of which is sometimes distinctly facetted, as if by contact with a portion of the outer end of the trapezium, but the evidence of such contact is not always present and it is wanting in the bone figured. Distally the internal surface is produced into a dorsi-ventrally depressed ridge.

The external surface, which like the internal shows the considerable vertical depth of the proximal end, bears contiguous to, and distad of, the facet for the magnum (n B), a vertically disposed narrow facet which abuts against the side of the base of the third metacarpal (pl. IX., D). As these two tracts are generally continuous with one another in the same plane they are not often separately demonstrable, but in the bone figured a distinct though very obtuse angle of junction delimits the respective surfaces and this has been artificially accentuated by a pencil line which appears in pl. IX. between the upper Band D.

Dorsally this metacarpal bears, at the junction of the proximal and middle thirds, a prominent tuberosity (pls. VII. and VIII., II., E) which extends up to, or even encroaches npon, the outer border but which does not reach the inner. Its surface may be either rough or facetted.

The distal end of the bone is expanded into a distinct head whose outer, larger and deeper portion forms an articular prominence for the first phalanx. Of this the vertical convexity is considerable, and it encroaches well upon the dorsal, but not upon the palmar, surface.

The part of the bone internal to the phalangeal articular convexity is depressed and inwardly produced (pls. VIII., II., F), forming the continuation of the depressed ridge described in connection with the distal part of the internal surface. The outer side of the head presents a smooth and flattened, subcircular tract suggestive of contact with the head of the middle metacarpal.

M. III. is slightly longer than the preceding and presents a similar, though less, considerable dorsi-palmar depth at its base and a more gradual attenuation. towards the head (pl. VIII., IL). The proximal surface articulates with the magnum by a rectangular, flat or slightly concave facet (pl. IX., G) the obliquity of whose plane has a marked inward inclination so that when set againRt the magnum the head of the bone is deflected in the same direction. In some examples, as in that figured, the dorsal part of this facet shows a non-articular notch (pls. VIII. and IX., H).

On the inner side there exists, contiguous to, and distad of, the border of the proximal facet, a narrow vertically disposed articular tract (pls. VIII., III, I) which impinges against the side of the base of the second metacarpal. In advance of this articular border the vertical height of the bone diminishes gradually towards the head by convergence of its superior and inferior surfaces and the inner surface becomes so inclined to the outer that, at the middle of the bone, the section is sub-triangular, the dorsum of the bone constituting the base of the triangle. By a small and generally vertically elongated facet (pls. IX., J), contiguous to that for the magnum, the external surface abuts against the side of the base of the fourth metacarpal. In advance of this the surface is flat, rough, somewhat tuberculated and repeats the feature of the internal aspect in the gradual diminution of the vertical depth as the distal end is approached.

The dorsal aspect (pls. VII., III) is flat, and its inner border bears, towards the base of the bone, a small flattened tuberosity which encroaches upon the inner surface (pls. VII. and VIII., III., K). Not unfrequently there is on the opposite border, and rather nearer to the base than the former, a second smaller prominence.

The palmar surface is relatively narrow and rough.

The head, somewhat flattened on either side, presents a prominent articular convexity for the proximal phalanx which encroaches well upon the dorsal surface and also, by its infero-external angle, to an equal distance upon the palmar aspect.

M. IV. A metacarpal somewhat similar to *M. III.* but very slightly longer and more massive than the preceding, and showing also considerable vertical depth at the base, with progressive attenuation towards the head (pls. VIII., IV.). The proximal end articulates with the unciform by a parallel-sided quadrilateral tract (pls. IX., L) which, in its aspect and in the obliquity of its setting, is somewhat similar to the corresponding face of its predecessor but it differs from the latter in its greater transverse breadth. In that direction this facet is usually gently concave, but in some examples this feature is so marked &s to produce the appearance of & vertical groove.

The inner surface (pls. VIII., IV.), so markedly concave in its long axis as to give the bone a somewhat bent appearance, bears, contiguous to and distad of the proximal surface, a distinct, semilunar or elongated facet (M) for the third metacarpal which approaches nearer to the dorsal than to the palmar border and which, not unfrequently, stands on a base slightly elevated above the surface of the bone in front of it. This surface does not show the same inclination of its plane towards the outer side as does the corresponding surface of the middle metacarpal and consequently the section at the middle forms, more nearly, a quadrilateral figure.

Externally the bone presents, distad of the unciform surface, contiguous to it and coextensive with the v0rtical depth of the base, a facet which is in contact with the fifth metacarpal; slightly in advance of this there is, near the palmar border, a roughened tuberosity.

The dorsal surface (pls. VII., IV.) is flat or only slightly convex transversely and both inner and outer borders end in small tuberosities. The palmar surface is irregularly rugose, and the head forms a vertical convexity somewhat similar to that of the third metacarpal.

The third and fourth metacarpals bear a certain amount of resemblance to one another particularly as the characters of either are apt to vary and merge into those of the other. The former may, however, generally be distinguished by its more slender build and slightly inferior length; by the transversely narrower base, sub-triangular section and by the prominence of its dorsal tuberosity.

M. V. This remarkable metacarpal, whose true nature was recognised by Owen*, has its ulnar side produced in such a way that its contour may be likened to that of the quadrant of a circle (pls. VII., Y.)# Its base, or proximal end, bears on its inner two-thirds, for articulation with the unciform, a large transversely concave facet of the form of a truncated oval, the line of truncation corresponding to its internal border (pls. IX., N). To the outer side of this facet the vertical depth diminishes and it is, there, non-articular, vertically convex, rough or more or less grooved.

With the base of the fourth metacarpal it is in apposition by an elongated, vertical tract on the inner surface, contiguous to and coextensive with the vertical height of the proximal facet (pls. VIIL, V., O). In advance of this the surface diminishes rapidly in vertical depth and, towards the head of the bone, bears a rough tuberosity (P).

The outer surface, corresponding to the arc of the quadrant, is, by the progressive reduction of thickness, reduced to a narrow roughened border which exhibits a notch about its middle (pls. VII., v., Q) and which may be said to end in a low and, generally, smooth tuberosity (R). The slight emargination shown in the figure between this (R) and the head of the bone IS also sometimes exaggerated into a notch as consplscuous as that just mentioned.

---

* Extinct Mammalia of Australia, p. 508 (Text). PLS. CXXII., figs. 7-10.
# In the bone figured the outer border is not as curved as is sometimes the case-a feature which, to some extent, detracts from the accuracy of the simile.

The dorsal surface (pl. VII., V.) is flat or gently undulating, with a, gradual subsidence of level longitudinally, from the proximo-internal angle to the outer border. Two or three of these metacarpals, of which very few exist in the collection, show evidence of immaturity in an episphysial junction which delimits the head and then runs concentrically with, and about half an inch internal to, the outer margin for its whole length; in some other bones the previous existence of this junction is indicated by a, correspondingly situated ridge. Close to the angle of the proximal and internal borders is a somewhat prominent tuberosity (pl. VII., V., S),

On the palmar surface there is, in advance of the unciform facet, a more or less rugose transverse tract or ridge and another which takes its rise just posterior to the head and runs nearly parallel to the former. These two raised tracts define a shallow, smooth channel which, curving with an outward sweep, ends in the notch mentioned as occurring about the middle of the external border. Either a single large foramen or several small vascular orifices occur about the middle of the palmar surface.

The head forms a, convexity whose prominence is accentuated by tbe emargination of the external border just behind and external to it. Its articular surface consists of a superior portion, convex in form, which extends well on to its dorsal surface and from the inferior part of which there diverge, on the palmar surface, two small and somewhat flattened facets which by their character would appear to have borne a pair of sesamoid bones, and indeed such ossicles were sometimes found in this situation.

PHALANGES, Pls. VII., VIII., IX.

The numbers of the phalanges of the manus conform to the normal mammalian formula.

PROXIMAL SERIES.

The first to the fourth have a close general resemblance to one another while the fifth is distinguished by its greater transverse breadth, due to the prominence of its outer border. No.1, also, has certain features by which it can generally be recognised, but it will be convenient, in the first place, to describe collectively Nos. 2, 3 and 4 of this series, which are very closely alike.

These are short, depressed bones, the depression being most marked fit the distal end of which the tranverse breadth is about two-thirds of that of the proximal, the latter dimension being nearly equal to the antero-posterior length.

Each proximal surface (pls. IX., 1.- v,) presents for the metacarpal a nearly flat, semicircular facet of which the curvature corresponds to the dorsal border. The distal articulation follow; a depressed trochlea, the palmar moiety of which exceeds the dorsal in transverse width besides encroaching more upon the palmar, than does the dorsal upon its own, aspect. The latter is convex transversely, while the palmar surface is nearly flat.

These three phalanges which are known to belong to their assigned places show H slightly diminishing size from the radial to the ulnar side and *Ph. II.,* 1*, besides its slightly greater basal breadth, may generally be distinguished from the other two by a certain amount of production of the proximo-internal angle, a feature which offers a, slight degree of obliquity on the plane of its base (pls. IX.).

Ph. I., 1, is shorter and broader than the three just described, and the degree of depression is slightly greater at its proximal, and slightly less at its distal, end. The obliquity of its proximal surface (pls. IX.), due, as in *Ph. II,* 1, to the production of the proximo-internal angle, is somewhat more marked than in the latter bone and, moreover, the prominence of proximo-external angle gives an emarginate appearance to the outer border which is generally a marked feature in this phalanx (pls. IX.). The character of the distal trochlea, though unsymmetrical from the greater development of the palmar moiety, is somewhat better defined than in the other phalanges of the series, and its lesser degree of depression has already been noticed.

Ph. V, 1. This phalanx is a depressed sub-quadrilateral bone, the breadth of which is equal to, or slightly in excess of, the length; the former dimension, taken at its middle, being nearly twice that of *Ph. I,* 1, the next widest of the series. This feature is largely due to the production, externally, of the outer border (pls. VII., and IX., v.); thus it repeats on a minor scale the conspicuous feature of the fifth metacarpal. The inner border is slightly concave anteroposteriorly.

The proximal end (pls. IX., v.) bears a transversely oval facet for the metacarpal which occupies the inner and deepest part of that surface, and does not extend to the outer and most depressed portion of the base. The distal end, of which the internal angle is somewhat anteriorly and internally produced, shows a marked amount of depression and its articular surface forms a transversely elongated, trochleariform facet, of which nearly the whole is situated on the palmar aspect.

The dorsal surface is transversely convex and the palmar somewhat concave, the latter feature being partly due to a certain amount of production, internally and palmad, of the antero-internal angle.

SECOND SERIES

The four outer toes possess, as their second segments, bones of which the shape and proportions closely resemble one another and, as there is no structurally equivalent segment in the pollex, it will be convenient here to regard this, the second phalangeal, segment as the absent element in the first digit. The greater resemblance of the pollicial metacarpal to the proximal phalangeal series than to the other metacarpals has been mentioned.

As in the first series, the second phalanges of digits *II, III,* and *IV* closely resemble one another, while that of digit *V* has characters which generally enable it to be distinguished.

---

*See footnote to p 14

The general characters of the similar members of this series are those of short, depressed, quadrangular bones with slightly indented lateral borders, the length of the bones being about equal to the breadth of the proximal end and that of the latter slightly exceeding the corresponding dimension of the distal extremity.

The proximal end (pls IX.), more depressed than the distal, presents over its whole extent a transversely oval facet, the centre part of whose dorsal border is produced posteriorly into an obtuse-angled process, the result being to somewhat increase the otherwise very slight vertical concavity of the facet and so to add to the efficiency of the joint.

The distal end is also wholly occupied by a shallow, trochleariform facet, for the ungual phalanx, whose dorsal and palmar margins encroach, to all equal extent, upon those surfaces respectively.

Of the three pbalanges which answer generally to this description, *Ph. II,2,* is slightly shorter than the other two, which are almost exactly of the same size and shape.

In the fifth digit this segment is of about the same length as those of the third and fourth, but it is distinctly broader, particularly at its proximal end where the increased width is due to a slight production externally of the proximo-external angle (pls. VII.). These features, with a somewhat greater depression, allow this segment to be readily distinguishable from the other three. Corresponding to its greater breadth the proximal articular surface (pls. IX.) is more elongated, transversely, than in its fellows of the series and ill the distal trochlea, also relatively wider, the facet makes a greater encroachment upon the palmar surface than it does upon the dorsal.

TERMINAL SERIES

The five terminal segments, which have all the characters of ungual phalanges, appear to have been approximately equal to one another in size and form, though the different degrees of apical abrasion preclude an exact comparison of their lengths. In this respect they are about twice as long as the members of the preceding series, and about half as long again as the proximal set.

The four outer segments, which are those between which the resemblance is closest, are sub-falciform and, if the base be excepted, sub-compressed elements with flat and nearly parallel, or with only very slightly apically convergent, sides. The dorsal surface is strongly convex transversely, less so longitudinally; the palmar flat and concave, respectively, in like directions.

In no example is the apex, which is composed of very porous and friable bony tissue, completely perfect but, judging from the approximate parallelism of the sides as far as these maintain their integrity, they may have been rather obtusely pointed.

Of the proximal ends (pl. IX.) the dorsal border is produced, posteriorly, as a, thickened margin somewhat to the rear of a corresponding, though less definite, production of the palmar border.

The lateral borders of this surface are also somewhat thickened, so that the base of the bone appears circumscribed by a sort of rim or collar. The articular surface forms a vertical concavity which accurately adapts itself to the distal trochlea of the preceding segment.

The distal abrasion does not permit of exact definition of the apical characters in the perfect condition.

The palmar surface bears, near to the base, a well marked flexor process. This is perforated on either side by a large foramen, and from this point of meeting of the two surfaces, a considerable vascular channel traverses the cancellous tissue towards the apex. Minute vascular pores also occur distad of the basal rim. Between the ungual phalanges of the four outer toes; it is scarcely possible to distinguish in a mixed collection, but that of the first digit, though of approximately similar form, is less compressed or may be even slightly depressed and it is consequently a broader and generally stouter segment than its fellows. These features are shown in pls. VII. and IX.

THE PES

As in the case of the manus no individual hind-foot could be completely restored; indeed the imperfections in the latter members were considerably greater than in the former. The hind-foot figured, in half size, on plate X. is thus a composite to greater extent than the fore-foot. It is made up of a complete set of tarsals from one member, of a similarly natural series of phalanges from another, and, of the metatarsal, the first, fourth and fifth, which belong to one another, are from a third foot, while the second and third are odd bones. It should perhaps be stated that the ecto-cuneiform being much broken has been partially made up with plaster, but this repair chiefly, but not exclusively, affects the inferior parts that are not seen in the figure.

Of the various bones subsequently figured in full size, either separately or in series, the tarsals and metatarsals have been selected for the same reasons as influenced us in the case of the manus, but in the hind-foot it has been found possible to use right bones, throughout, for separate illustration. The phalangeal series reproduced on the larger scale is the same as that figured with the whole foot, except in the case of the proximal end of the middle phalanx of the third digit (pls. XVIII.) where a perfect bone has been substituted for one slightly damaged. Of the metatarsals so figured the fourth is probably slightly oversized for conformity with its fellows. The phalangeal series belongs to a foot of medium, or even of a rather small, size, and in this respect it fairly well corresponds to the tarsus. Partial reconstruction, therefore, being necessary for both manus and pes it may be as well to state that we have been able to verify the exact nature of the articulation between individual bones by reference to specimens in which their relative positions have been preserved; the exception to this statement being in respect of the precise nature of the junction between the proximal phalanges and metacarpals, a question to which attention will be subsequently called.

ASTRAGALUS.

Pl. XI. and Pl. XII., fig. 1.

The astragalus is a depressed bone, considerably larger than any other bone of the tarsi except the calcaneum, whose general form may be likened to that of a wedge having the: inner portion of its base produced anteriorly into a very conspicuous and sub-hemispherically shaped head.

Its proximal surface (pls. Xl., fig. 1), the plane of which is directed inwards and forward: as well as upwards, forms an extensive articular area (A) for the tibia. This is of a remarkably even flatness over all, with the exception of the part adjacent to the middle of the inner border, which is raised into an obtusely angular prominence (pls. XL, figs. 1, 3, 4, B).

The external surface (fig. 4) is represented by a triangular, nearly flat, or very gently concave, articular tract (pls. XI., fig. 1, c, fig. 4, c, D, and pls. XII., fig 1, c), which is continuous, superiorly, with the whole length of that for the tibia, and is inclined to the plane of the latter at an angle somewhat greater than a right angle. Of this the anterior or wider portion (c) is adapted to, and has abutting against it, the distal articular surface of the fibula, while the posterior and narrower (fig. 4, D) has resting upon it the os pyramidale.

The internal surface (fig. 3) has produced on it, from the front, a narrow, elongated, and triangular extension of the articular surface of the head (E), immediately above and below which is a rough depression (F and G), the latter being pit-like in its depth. The remaining portion of this surface is non-articular and rough. In some astragali, however, an extension of the superior tibial tract encroaches on to the inner surface; in such cases there is to be seen on that aspect a narrow, articular strip lying contiguous to that part of its upper margin which lies in advance of the summit of the obtusely angular prominence previously referred to.*, With this, also, the tibia is in contact.

On the anterior aspect (pls. XII., fig. 1), or on that which has been likened to the base of the wedge, the inner part is produced, in advance of the remainder, into a large and prominent, semiglobular and even convexity (E) (pls. XL, figs. 1-4, and pls. XII., fig, 1) which fits into a cup to the formation of which the calcaneum, cuboid and navicular contribute. A part of the internal border of the head encroaches posteriorly, as has been mentioned, on to the internal surface.

External to the head the anterior surface is flat, non-articular, inclines backwards as it descends, and is beset with vascular foramina.

On the plantar aspect (pls. XI., fig. 2) the articular surface of the head is continued backwards as a relatively narrow neck, and then expands into a broad and shallow saddle shaped articular tract (H) which rests upon the calcaneum.

In a limited few of the numerous astragali in our collection-and we may add that, excepting ungual phalanges; we posses more of these bones than of any others either of the manus or pes- the form of the plantar surface differs from that of the great majority in

---

#*Vide* pl. XI, fig 3, where this tract is shown extending from towards the head being relatively less wide laterally, and more deeply excavated in the antero-posterior direction. This feature is conspicuous when the bone is viewed from the inner side, and appears due to the greater prominence of the posterior margin of the articular surface, particularly of its more internal part. We notice the same features in a single well preserved astragalus from the Diamantina District. The peculiarity in question is not associated with any difference of size, for they occur in the larger as well as the smaller specimens, and we doubt therefore that it is of sexual import.

CALCANEUM.

PLS. XIII.

This great bone, in size far exceeding any other member of the tarsus, has a conspicuous curvature due to the internal inflection of the non-articular, posterior or fulcral, moiety which forms rather more than one-half of its antero-posterior length (fig. 1).

Of the anterior portion the superior surface provides, for the astragalus, a large subreniform facet (pls. XIII**.,** fig. 1, A, A, A), the surface of which is, to some degree, undulating, but on the whole concave. This surface, when the bone is in position, slopes somewhat steeply downwards and forwards, and becomes definitely concave as it descends to that part which forms part of the cup for the head of the astragalus. That which corresponds to the hilum of the sub-reniform contour (B) is due to the intrusion, on the outer side, of a deep, nonarticular depression for ligamentous attachment which is large enough to admit the tip of the thumb. This depression, when the two bones are in position, underlies the non-articular area on the anterior surface of the astragalus external to the head

The anterior surface, reduced to relatively small dimensions, has a sub-oval concavity for the cuboid (pls. XIII**.,** figs. 1 and 2, c); of this the supero-internal margin, which is coincident with the anterior border of the astragalar surface of the calcaneum, abuts against the postero-external margin of a concavity of the cuboid, so that the two concavities, viz., ot the cuboid and of the front part of the superior calcaneal articular surface, become evenly continuous as parts of the cup-shaped depression which receives the head of the astragalus. Internally to the calcaneal concavity for the cuboid, for a distance of from two to three inches, the internal margin of the astragalar tract of the calcaneum (pls. XIII., fig. 1, from D to opposite the lower A) abuts against the posterior edge of a large concave surface of the navicular, thus completing the formation of the astragalar cup *(vide* pl. X., fig. 2).

The external, internal (fig. 2) and plantar surfaces of the anterior half of the calcaneum are rough, rugoso, or tuberous.

Of the fulcral portion, to which, as has been mentioned, the pisiform bears a striking resemblance, the dorsal surface (fig. 1,E) is prominently convex and slopes somewhat steeply posteriorly and plantawards, while on the latter aspect it is nearly flat or only slightly convex in a transverse direction.

The posterior surface, seen in profile in fig. 2 (F F), is reduced to a narrow tract of small vertical height but of considerable transverse extent and curvature; it is usually, as in the bone figured, bordered above and below by highly corrugated ridges which define an intervening groove; or, in other cases, this tract may be only generally rugose.

Out of 22 calcanea, in fairly good condition, the length of the longest specimen (measured from the centre of the concavity for the cuboid to the most distinct posterior point) is 226 mm., the shortest 182 mm., and the mean length 206 mm.

THE CUBOID.

PLS. XII., figs. 2-5.

There will be some convenience in describing this bone first amongst those of the second row of the tarsus. The remainder will be dealt with in the usual order from the tibial side.

The cuboid is a compact bone, the shape of which fairly well corresponds with its name. Its proximal aspect (fig. 2) presents a, relatively, large concavity (figs. 2 and 5 A) and, more externally, a smaller convexity (B). These are contiguous but inclined to one another at an obtuse angle.

The former, of remarkable variability in outline but generally approximating, more or less, to a sub-circular form, is a uniform depression which is directed postero-internally and, by the meeting of its posterior border with that edge of the calcaneum which is common to its astragalar and cuboid facets and of its antero-internal border with the edge of the astragalar concavity of the navicular, it forms about one-quarter of the cup for the head of the astragalus *(vide* pls. X., fig. 2 s).

The convexity (B) on the proximal surfaces, more externally situated, is more or less oval in form and articulates with the concavity on the fore end of the calcaneum.

By the antero-internal aspect (fig. 3) the cuboid articulates with the navicular and ecto-cuneiform; to the former by a, usually, elongated tract (C, C) which lies contiguous to and distad of the inner border of the concavity for the astragalus The lower end of this is continuous with a facet of variable size (0), situated on the plantar aspect of the bone, which makes an obtuse angle with the former. These combined facets, forming together an angular tract, are received within that which will be described as the re-entrant angle of the outer end of the navicular. To the ecto-cuneiform the cuboid articulates, chiefly, by a small flat facet (F.) situated close to the antero-superior angle of this (antero-internal) aspect; a second smaller facet (F), for articulation with the same bone also, frequently, occurs near to the plantar border, and is contiguous both to the lower end of the upper moiety (C, C) of the articular facet and to its plantar extension (D). The remainder of this face of the bone is non-articular and, in the central region, is more or less depressed into a hollow.

The distal aspect (fig. 4) presents, over the greater part of its extent, a sub-circular and nearly flat articular surface (G, H) of which, by far, the greater part (G) supports the base of the large fifth metatarsal, a narrow vertical tract only (H), lying contiguous to the inner border, being in contact with the edge of the wedge-shaped base of the fourth metatarsal. The latter tract is not generally demarcated from the former, but the two form one uninterruptedly continuous surface. Below the articular tract the surface of the bone recedes posteriorly and terminates in a large and slightly convex tuberosity (J) which encroaches on to the plantar aspect and generally forms a conspicuous feature in the bone.

The dorsal surface (fig, 5, K) is flat or slightly concave and the external somewhat prominent, while the plantar, exclusive of the small facet (n) for the navicular, is non-articular and is encroached upon by the tuberosity (J) mentioned in connection with the distal aspect.

NAVICULAR.

PLS. XIV.

This is a large and elongated bone placed so obliquely in the foot that its long axis lies nearly parallel to that of the calcaneum *(vide* pls. X., N) and so irregular in form that it is difficult, for purposes of description, to assign to it definable surfaces. At the same time a good deal of variation of detail exists in different bones.

The posterior and inner half, mostly non-articular, may be described as somewhat antero-posteriorly compressed and, consequently, as exhibiting considerable dorso-plantar width, while the anterior and outer moiety, to which are chiefly confined the articular surfaces, has its greatest width in the direction of the axis of compression of the former, the dorso-plantar width being correspondingly less. These features are best shown in figs. 1 and 3, which represent the proximal find the anterior, or more accurately the antero-internal, aspects respectively. The anterior two-thirds of the proximal surface is excavated intv a concavity (figs, I, 3 and 4, A) which contributes about one-third to the formation of the astragalar cup. The antero-external margin of this concavity is deeply notched so that it forms a reentrant plane angle, into which the previously mentioned angular facet of the cuboid is received *(vide* figs. 1 and 4, where B stands at the apex of the re-entrant angle).

The external surface, of small extent, consists of a relatively narrow articular tract for the cuboid (pls. XIV., fig, 4, 0, B, n) which is conformable to the trend of the sides of the reentrant angle. The inferior arm (n) of this angular tract is the wider of the two, and it is adapted to the plantar extension of the navicular tract of the cuboid *(Vide* pls. XII., fig. 3, n) while the superior arm (C) abuts against the elongated tract on the antero-internal surface of latter bone *(vide* pls. XII., fig. 3, 0, 0).

Contiguous to the superior and narrower arm of that which has been described as a reentrant angular facet for the cuboid, but distad of this and inclined to it at an angle, is a nearly flat or only slightly concave ovoid facet for the ecto-cuneiform (pls. XIV., fig'. 4, E). This facet is further continuous, internally, with a long and narrow articular tract for the combined ento- and meso-cuneiform (fig. 2, F, F) which is situated on the distal or antero-inferior surface. This facet is markedly convex in its shorter axis and its posterior border is defined hy a deep, concurrent groove. Internally to this the surface is produced antero-inferiorly into a prominent rugose, non-articular tract *(G),* which forms the inferior portion of the expanded inner moiety of the bone.

The antero-internal surface (fig. 3), narrow externally, but wide internally where it corresponds to the compressed inner and hinder portion of the bone, is uneven and irregularly rough and rugose. The opposite, or postero-external, face is also correspondingly wide at its inner part, while, more externally, the excavation which provides the astragalar concavity brings about a rapid diminution of its width till the surface terminates at the border of the inferior moiety of the facet for the cuboid.

The postero-internal surface is represented by a vertically elongated rough, or tuberous, non-articular tract which corresponds to the region of greatest compression of the bone.

ENTO-CUNEIFORM.

Pl. XV., figs. 1-3.

An irregularly elongated bone, distally articulated to the navicular, which, from its relations to that bone and to the first and second metatarsals, must be considered as representing the combined inner and middle cuneiforms. And indeed evidence of synostosis exists in the constriction of the outer end (figs. 2 and 3), in the presence of a considerable foramen perforans at the point of constriction* which, in one or two cases, amounts to it partial fissure and in a fine but distinct groove which, in the bone figured, traverses the facet for the navicular in the same region (fig. 1, B).

To the navicular this combined bone articulates by a long and narrow facet which occupies nearly the whole length of the proximal surface (fig. 1, 0, B, D). This is concave in the shorter axis, and the surface of that part of it (0) which corresponds to the small meso-cuniform moiety lies in a plane which makes a very obtuse angle with the remainder. Continuous with the external end of the former but inclined to it at an angle little greater than a right angle-situated, in fact, on the external end of the bone-is a small, semi circular facet which abuts against a correspondingly shaped tract on the postero-internal facet of the ecto-cuneiform (figs. 1 and 3, E).

In one or two, but not in all, of the very few good specimens of this bone that we possess a second, rather smaller, facet occurs on the external end distad of that just mentioned (fig. 3, F). This, from its position relatively to the other, should also articulate with the ecto-cuneiform, but on none of the latter can we find evidence of a corresponding tract. It might possibly touch the side of the base of the third metatarsal, but, here also, our limited number of bones does not enable us to establish this point with certainty.

The distal aspect of the ento-segment is hollowed into a concavity, conformably to its long axis, which encroaches somewhat upon the dorsal surface. The concavity receives the base of the short and stout first metatarsal, but direct contact with that bone appears to be confined to a transversely oval, nearly flat, tract (fig. 2, G) lying towards the external portion of the concavity. For the remainder the two bones, though in close contiguity, do not appear to have been in actual articular contact. The distal surface of the small meso-cuneiform

---

* One orifice of this foramen is indicated, in fig. 2, by an elongated dark spot just to the right of the facet on which H stands; other orifice, considerably larger, is seen on the dorsal aspect, and is obscurely indicated in fig. 2, by the dark spot just below A.

segment bears a small sub-circular facet (fig. 2, H) for the second metatarsal. The dorsal (fig. 2, D) and plantar (fig. 3, K) surfaces are somewhat rough, but call for no special description, and the internal extremity is rugose, directed plantad and is, as it were, jammed in between the navicular and first metatarsal (pls. X., figs. 1 and :2).

ECTO-CUNEIFORM.

PLS. XV., figs. 4-6.

The ecto-cuneiform has the shape of a quadrilateral pyramid, with the apex somewhat truncated and inferior. By its proximal surface, which is directed postero-internally, it articulates with the navicular by an oval, or pyriform, saddle-shaped tract (fig. 4, A) which occupies the superior three-fourths of the whole surface, leaving only a small non-articular tract near the apex.

Its postero-external surface (fig. 5) meets the cuboid by two small sub-circular facets, one of which (c), barely elevated above the surrounding surface, is situated close to the antero-superior angle of this aspect, where it is continuous with the metatarsal articular tract of the distal face·(F); the other facet (lower D in fig. 5) lies close to the truncated apex and is usually situated on a raised-sometimes a very considerably raised-base. All of the remainder of this surface is non-articular and generally flat.

The antero-internal surface (fig. 4) presents close to its posterior border, and contiguous to the navicular facet, a semicircular tract (E) for the facet that has been mentioned as occurring on the outer end of the ento-cuneiform.

Distad the dorsal two-thirds of the surface is occupied by an articular tract (fig. 6, F, F, G), of which by far the greater part (F, F) supports the inner side of the wedge-shaped proximal end of the fourth metatarsal. The much smaller third metatarsal, however, also abuts against a narrow vertical section (G) on the inner side of this face. The plane of the latter portion is usually, as in the bone figured, differentiated from the former by the difference of inclination of its plane.

The dorsal surface (fig. 7, D), constituting the base of the pyramid, is flat or slightly convex and rough, and would be quadrilateral but for the slight truncation of the antero-internal angle produced by the inclination of the plane of the small tract, just mentioned, for the third metatarsaI. This feature is not, however, evident in the figure. The plantar surface representing the truncated apex of the pyramid is reduced to a small rough nonarticular tract.

METATARSALS.

Pls. XVI., XVII, XVIII.

*M. I.** The single element representing the hallux is a short, stout bone, the longitudinal axis of which makes nearly a, right angle with that of the other digits.

**Vide* footnote on p14

28

The proximal end (pls. XVIII.), obliquely bevelled at the expense of the dorsal surface and, by the divarication of the bone, directed externally, bears an oval facet (pls. XVI.-XVIII., A) for the ento-cuneiform; this, as a rule, is confined to the plantar part of this surface, though it may occupy the whole.

The distal end is, in the majority of examples, represented by a, more or less, rounded and rough head, but in some cases it is somewhat depressed, by which feature it assumes a certain amount of lateral expansion, which is expressed chiefly in the production of its anterior border. Under these circumstances the anterior surface of the bone is longitudinally concave.

Dorsally, posteriorly, and inferiorly the surface of this metatarsal is non-articular.

M. II. As has been previously indicated the metatarsal occupying this position in the articulated foot, represented in pl. X., is a substitute and, moreover, our choice of a suitable bone was limited by the fact that we possess only two or three perfect specimens of this segment. Further, the bone figure as belonging to the mounted foot is probably a somewhat aborted specimen of its kind.

Considerably compressed at its proximal end (pl. XVIII., B) this absurdly small metatarsal is somewhat depressed at its distal termination and the whole bone exhibits ,a marked plantar curvature (pl. XVII., lr.). The former end articulates with the small facet on the distal surface of the meso-segment of the ento-cuneiform by an ill-defined articular tract (pls. XVI, XVII., and XVIII., B) which is situated well on the dorsal surface, and rather inclined towards the inner side of the base. Plantad of this there is a small rounded tuberosity.

The distal end presents for the first phalanx an obscurely marked convexity (pl. XVII., II., c) which extends on to the dorsal surface of the head.

Of the only two other second metatarsals perfect enough to admit of measurement one is half as long again and about twice the thickness of that described; the other is only a little longer, but still twice as thick.

One of these-a right bone, separately figured on pls. (XVI., fig. 2, and XVII., figs. 2 and 3) which, had it not been at first overlooked, might with advantage have been substituted for that incorporated with the articulated foot-has less of a distorted appearance than the latter, but it exhibits a similar plantar curvature and some amount, though a less degree, of compression of the head. Its convexity of articulation with the ento-cuneiform (B), rather more definite in character than in the example previously described, is similarly inclined towards the inner aspect and, on the outer aspect, som8what in advance of its proximal border, there exists a well marked circular, flat facet (pls. XVII., fig. 2, D), by which it appears to have been in contact with the inner side of the base of the third metatarsal.

M. III. Of this bone, also, we possess few perfect examples and, like the preceding metatarsal, that in the articulated foot is a substitute.

From about once and a half to twice the length of its predecessor in the series it is nevertheless a small bone for a foot of this size. It exhibits a slight degree of plantar curvature, the effect of which is exaggerated by the considerable plantar production of the laterally compressed base (pls. XVII., E). The dorsal part of the proximal end bears a small facet inclined somewhat obliquely towards the inner side by which it articulates with the ecto-cuneiform (pls. XVII., 1II., and pls. XVIII., E) while, on the internal surface a little distad of the proximal border, there is sometimes, but not always, a distinct circular and flat facet (pls. XVII., III., F) which would appear to have impinged against a corresponding and similar facet on the outer surface of the small second metatarsal. On the external aspect of the bone, contiguous to the ecto-cuneiform facet, there is, in the bone under description, a smaller facet which seems to have abutted against the fore part of the large articular tract on the inner surface of the vertically expanded base of the fourth metacarpal. Raplsdly diminishing in vertical depth as it advances, the bone terminates in a sub-compressed articular head.

M. IV. This metacarpal greatly exceeds in size that of its predecessor in the series. Its conspicuous feature is the great dorso-plantar expansion and wedge shaped form of its proximal end which confers on that part a vertical depth which is not far short of the length of the bone (pls. XVII., IV.). That which corresponds to the somewhat truncated edge of the wedge forms a narrow vertically disposed tract (pls. XVII., IV., and pls. XVIII., G) for the inner part of the distal surface of the cuboid. Contiguous to, and distad of, this is a large vertically placed oval, or semicircular, tract (pls. XVII., IV., and XVIII., H, H) with which this bone is in contact with the ecto-cuneiform. This is coextensive with almost the whole vertical width of the proximal end of the bone, and its plane is inclined so obtusely to the previously mentioned facet that the two sometimes appear to be uninterruptedly continuous with one another,

The outer side of the base abuts against the inner side of the fifth metatarsal by vertically elongated facet, which occupies the superior four-fifths of its vertical extent.

In advance of the expanded proximal end the dorsal and plantar surfaces of the bone converge towards one another, at first, very steeply then more gradually, thus producing great reduction of the vertical depth of the bone. The outer surface bears a low rough tuberosity, situated a little in advance of the lower end of the facet for the fifth metatarsal.

The distal end forms a very prominent, almost, conically shaped convexity, which, on its plantar aspect, bears evidence of having been in contact with a pair of sesamoid ossicles.

M. V. This metatarsal, which, in most respects, has the peculiar features of the corresponding metacarpal, is, like the latter, characterised by the great lateral expansion of the outer side. Comparing the two bones, however, that of the foot is longer in proportion to the breadth, there is greater plantar production of the proximal infero-internal angle, more general and distinct concavity of the plantar surface, and the angle contained by the proximal and internal surfaces is greater than in the fifth metacarpal. From the last mentioned feature it results that, when this bone is articulated to the cuboid its distal end is considerably deflected toward; the inner side of the foot, and a similar inclination is maintained by the next three metatarsal *(vide* p1. I.).

The proximal surface (pl. XVIII.), which rapidly diminishes in vertical depth towards the outer side, bears on the internal two-thirds a large, nearly flat, or sometimes transversely concave, articular tract for the cuboid (J), the shape being that of a transversely placed oval truncated vertically on its inner side. The outer third of the proximal surface, much diminished in height, is non-articular and projects considerably beyond the outer side of the cuboid.

On the internal aspect (pl. XVII., V.*)* a vertically disposed facet (K), contiguous to the truncated inner border of that for the cuboid, has abutting against it the side of the base of the fourth metatarsal. In front of this the internal surface, having suddenly diminished in vertical depth, preserves, thenceforward, to the head a nearly uniform breadth and is nearly straight, but owing to the inflection of the bone it has a marked inclination towards the inner side.

The distal end forms a convexity, the prominence of which is accentuated by the slight emargination of the bone just external to it; its inner side is marked by a depression, while its articular surface, not infrequently, indicates the existence of three continuous though separate facets. Two of these, inferiorly situated and contiguous though delimited by a feeble antero-posterior median ridge, have apparently supported a pair of sesamoid bones; the remainder of the articular tract, extending well on to the dorsum of the head, appears also to have, in part at least, given support to a similar ossicle. As will be seen in speaking of the proximal phalanges, the exact nature of the articulation between these and the metatarsals is not quite clearly defined.

The external surface, reduced to a comparatively thin arcuate border, is rough and tuberculated, and the evidence of the existence of the same kind of episphysial junction as that described in speaking of the corresponding metacarpal is apparent in the linear tract which runs internal to, and concentric with, the external border (pl. XVI., V., L, L).

Occasionally, but infrequently, a distinct notch occurs (as in the bone which forms part of the articulated foot) at, or in front of, the middle of the external periphery *(vide* pls. I.).

The dorsal aspect shows many vascular foramina and, in conformity with the excess of thickness of the part of the bone at the junction of the proximal and internal borders over that of the outer periphery, the surface slopes radially from the former to the latter.

The plantar surface is undulating, though the existence of a broad shallow trough, or depression, towards its anterior part gives it a general appearance of concavity. Just proximad of the head there is a considerable tuberosity, and the remainder of the plantar surface is in general rough. The external peripheral border, in particular, is very corrugated.

PHALANGES.

Pls. XVI., XVII., XVIII.

With the exception of the hallux, which consists of the metatarsal only, the digital phalanges of the pes correspond in number with the normal mammalian formula, and, as has been stated, these elements in the mounted foot, though forming a natural series, do not belong to the same foot as the tarsus. Though of average size, the series is, however, rather small in comparison with the metatarsals shown in collocation, which are relatively large.

PROXIMAL SERIES.

It will be convenient to begin with the description of *Ph. V,* 1.* Of this the general characters are those of a short, fairly stout and sub-depressed bone, which exhibits some production outwards and backwards of its proximo-external angle. This feature, affecting the proximal surface, confers upon it some amount of transverse obliquity (pls. XVI., figs. 1 and 3.) The conspicuous articular tract in connection with this end is a flat or concave facet (pl. XVI., M) of such a character that its position may best be described by speaking of the end as being bevelled off largely at the expense of the dorsal surface. The obliquity of the bevel exhibits varying degrees from little past the vertical to nearly the horizontal, in which latter case the facet rides almost completely upon the dorsal surface of the base. This facet would appear to have supported, in part at least, a sesamoid bone which, in one instance, was found in this position. In some examples there can be seen, plantad of this and more directly situated on the proximal end, a feebly expressed articular tract, which is more often than not confined to the inner side of the base. This appears to be the surface of apposition to the metacarpal, though if this be so the fit of the two bones is most unsatisfactory from the point of view of fixity and strength, while to bring the more considerable and, definitely, bevelled, surface (M) of the phalanx into proper apposition with the head of the metacarpal would require the axis of the former to be placed nearly, and in some cases quite, at right angles to that of the latter. In many specimens, however, the facet which has been spoken of as bevelled is the only one that exists; and where this is placed, as sometimes occurs, almost horizontally upon the dorsum of the base it is difficult to imagine what kind of an articular junction this was. In a few cases there is a lesser degree of bevel, and the phalangeal facet, being then almost perpendicular to the long axis of the bone, can be made to fit the head of the metacarpal so as to indicate a fairly normal and satisfactory joint, but in such an instance no part of the phalangeal fa0et could have borne a sesamoid.

In pls. XVI., fig. 3, a phalanx of this rank is separately figured. This not only represents, by way of comparison, the largest specimen of this sort in the collection, but shows also the single proximal facet almost terminally situated.

The distal end, more depressed than the proximal, bears a shallow articular trochlea, which is asymmetrical by reason of the greater extent of the plantar moiety; while the breadth of the latter is coextensive with that of the head the former is confined to the middle portion only. Sometimes, while preserving their relative inequality of size, the two, instead of forming a trochleariform surface, meet one another along a straight line.

Ph. IV, 1. N early as long as *Ph. V* 1, but only about half the width, while its distal end is sub-depressed. This cannot be said of either of the base or shaft. Proximally there is, on a diminished scale, the same kind of bevelled facet as that described for the pre-

---

*Vide footnote p14

viously described phalanx, and the same remarks are called for as to the imperfection ot its coaptation with its metatarsal. The head bears a distal trochlea, of which the transverse width exceeds the vertical depth.

Ph. III, 1. This bone shows a, still further, reduction of size, being a little shorter than, and about two-thirds of the width of, the preceding. The shaft is somewhat compressed and there is a similar, though less, degree of bevel in the proximal facet. The transverse breadth and vertical height of the distal trochlea are about equal.

Ph. II, 1. A slightly shorter segment than the preceding, but in other respects n very similar bone.

SECOND SERIES.

Ph. V.,2. A depressed sub-quadrilateral bone which bears a general resemblance to the corresponding segment of the manus, and which, like this, exhibits some, though a considerably less, degree of outward production of the postero-external angle.

The proximal surface forms a transverse oval, which is nearly flat in that direction, but slightly concave vertically. A very slightly expressed vertical ridge sometimes divides the facet into two moieties, corresponding to the convexities of the trochlear with which it articulates.

The head bears a saddle-shaped facet, of which the breadth considerably exceeds the height and the width of the plantar that of the dorsal border.

Ph. IV, 2. Somewhat shorter than *Ph. V.,* 2, about half the breadth, and relatively less depressed. The proximal facet is a shallow, transversely oval concavity; the distal a hemi-cylindrical convexity, with its axis transverse and having the height equal to the breadth. Between the head and base the bone is constricted.

Ph. III, 2, exceeds *Ph. IV.,* 2, in length, but is scarcely half its width. The proximal surface (somewhat damaged in the type specimen) appears, from others, to have formed a sub-circular flat or slightly concave facet. The head forms a vertical convexity very similar to that of the corresponding part of the precedent segment of the same digit.

Ph. II, 2. A shorter, but considerably stouter, element than tbe preceding having, however, similar characters to the proximal and distal ends. A small tuborosity occurs on the inner side towards the head, which feature is repeated in two of three other specimens.

TERMINAL SERIES.

Though, owing to abrasion of the tips, the exact lengths of the members of this series is; not determinable yet, so far as concerns the transverse breadth and, to a less degree, the vertical depth, there is a progressive diminution of size from the outer to the inner side. The abrasion, which has affected all specimens alike, also precludes an exact definition of the form, though it would appear by their present shape that there had been but little degree of plantar curvature *(vide* pl. XVII.).

Ph. II1. and IV., 3. The form of these segments is so similar that they may be conveniently described together. Being much laterally compressed their bases are thus of considerable vertical depth. From the dorsal and plantar angles of the base the corresponding surfaces incline rapidly towards one another in nearly straight, or only slightly curved, lines, till they reach the abraded ends. Thus the outline, when viewed from the side, is distinctly triangular.

The plantar surface near the base is produced into a flexor process which, as in the corresponding segments of the manus, is perforated on each side, the perforations leading into a median, and distally directed, channel. Small vascular foramina are numerous, particularly towards the base and tip.

The proximal surface bears an oval facet elongated and concave vertically (pls. XVIII.).

The third ungual phalanx is slightly narrower, both vertically and transversely, than the fourth, and its proximal facet conforms to these diminished proportions.

Ph. V,3. While showing in its mutilated condition a triangular shape similar to that of the preceding, there is considerably less compression, so that this element is conspicuously broader transversely, as well as deeper vertically, than these *(vide* pls. XVII and XVIII.). It would appear also to have been longer, so that it is altogether a larger segment. Bearing in mind these relative differences, which affect the base as well as the parts in front, the other features described for the third and fourth claw might be stated in very similar terms.

Ph. II, 3. This phalanx appears to have been even shorter and less curved than its fellows of the third and fourth digits· In front of the base its degree of compression is about the same as in its nearest neighbour, though the base itself is transversely broader. This is due to the production of the sides and dorsal border of the base into a sort of collar, which thus not only adds to the width, but which gives to the base a dorsal projection in excess of that which obtains in the other corresponding segments.

As compared with the homologous segments of the manus, those of the pes can be at once distinguished by their smaller and less uniform size, diminished length and curvature, and by the greater degree of compression. These features are very evident in the case of the second, third, and fourth claws, less so in that of the fifth, though even this may generally be distinguished by the greater basal vertical depth and triangular form.

OS PYRAMIDALE.

Pl. XVIII., fig. 2.

The single example of this bone belonging to *Diprotodon australis* that was obtained has suffered some abrasion of posterior part. Its shape is that of an elongated three-sided pyramid which, with the apex directed anteriorly, is wedged in a corresponding space that is left between the lower expansions of the tibia and fibula and of the astragalus, being in direct contact with all of these surfaces by its three sides.

Of these faces the internal, or that in contact with the tibia (N), is the narrowest and has a slight degree of fore and aft concavity. The external or fibular tract (0) is somewhat wider, but otherwise similar to the preceding.

These two surfaces are seen to meet dorsally towards the apex, but posteriorly their meeting is intercepted by an area of abrasion.

The inferior or astragalar surface is flat, and apparently has been about the same size as that for the fibula. Owing to the abrasion the posterior aspect, or base, does not admit of description, though it may be said that a portion of its natural, non-articular surface seen on the outer side obtrudes itself between the posterior limits of the astragular and fibular facets

REMARKS

The preceding descriptions suggest a few observations which may now be offered. There are to be found, both in the manus and pes of Diprotodon, evidences of its marsupial nature, with such adaptive modifications as might be expected to occur in structures in which other powers must have been entirely subservient to the ability to support and carry an enormous weight. Though the greater modifications to which the pes is subject in the Marsupialia render it a more important structure than the more generalised manus in determining affinities, yet we find marsupial traits in the latter as well as the former. Thus the pisiform, which by its size, strength, and position at once invites comparison with the fulcral portion of the calcaneum, exhibits the common marsupial feature of sharing with the cuneiform-and this to a more than usual extent and efficiency-in the formation of the ulno-carpal joint. In Diprotodon the supporting powers of these two bones receive an additional reinforcement by a contribution from the unciform to the ulnar concavity, and thus the superincumbent weight, transmitted through the semi-globular head of the ulna, is the more evenly distributed to the carpus.

The scaphoid has been described by Owen* as presenting points of resemblance to the corresponding bone of Macropus and Phascolomys, and by Lydekker# as agreeing" very closely with the corresponding element in Phascolomys and Phalangista.|| A general resemblance does, no doubt, exist between the scaphoid of the fossil and that of the three other types mentioned, the similarity being, in our oplsnion, most marked in the case of Phalangista, and least so in Macropus; but still the differences are considerable and, as instancing the risk of attaching too much value to resemblances of this kind, we may remark that we find this carpal bone of Diprotodon has a greater resemblance to the scaphoid of man than to that of any of the marsupial forms mentioned, particularly in the important respect of the amplitude and evenness of the radial convexity, the chief points of difference, in fact, being in the greater provision, in the human bone, for secure articulation with the trapezium and trapezoid. In the extinct marsuplsal. as has been mentioned, the characters of the articulation between the scaphoid and trapezium betoken deficiency both in security and strength.

---

* Ext. Mamm. of Australia, p. 508 (Text).

B.M. Ca.t. Foss. Mamm., Part V. (1887), 'p. 181.

||For purposes of comparison the skeleton of *Trichosurus vulpecula* has been used, uuder its more familiar generic name of Phalangista, as typlscal of the Phalangeridrae; and, except where specially indicated, *Phascolomys latifrons* has similarly served for the Phascolomyidrae.

The form of the magnum and trapezoid more nearly approximates to that of these bones in Phalangista than in Phascolomys or Macropus-in fact, the resemblance in the first named instance is even close; to a less extent this similarity obtains in the case of the unciform, bearing in mind that there is, in Diprotodon, no processus unciformis, as there is in the three living types mentioned. The comparison of the trapezium of the fossil with that of the other groups mentioned offers, as we might expect, points of dissimilitude rather than of resemblance; the same may be said of the cuneiform, if we except the fact that all alike share in the conspicuous feature determined by the contribution of this bone to the concavity for the distal end of the ulna.

With regard to the metacarpals, the conspicuous features are the great breadth and relative size of the fifth, which characters are determined by the production, ulnad, of its outer side. As has been noticed by Owen,* the fifth metacarpal of *Macropus (rufus)* "has a process extending outward from its base," but it is quite insignificant, and the production, such as exists, is backwards rather than outwards; moreover, it is confined to the metacarpal, and does not appear in the corresponding metatarsal. No trace of such a process exists in the fifth metacarpal of either Phascolomys or Phalangista, though it occurs as a conspicuous feature in the homologous metatarsal of both of these types. In Diprotodon, on the other hand, the outward production-and this to an extreme degree-is, as has been seen, a marked feature in both metacarpus and metatarsus, and though, in both, its degree reaches a maximum at the base, it yet affects, more or less, the whole of the outer surface. This bone, therefore, forms the mainstay of strength for the, otherwise, singularly weak, fore part of the foot.

A trace of external production appears in the proximal phalanx of the same digit, to which feature the relative breadth of the bone is partly due.

The characters of the trapezio-metacarpal articulation of the pollex, as already indicated, are such as to indicate great want of adaptive articular strength, together with limitations to range of movement.

The phalangeal portions of the digits, while segmentally conforming to the normal mammalian formula of the pentadactyle manus, exhibit a collective weakness, both in respect of the size of the bones and in the character of the joints. The metacarpo-phalangeal articulation of the pollex is, as has been stated, often limited to comparatively small tracts of the two surfaces that are opposed to one another and, under such conditions, the joint is singularly lacking in firmness and strength; so, also, the characters of the surfaces in actual articular contact and the close contiguity and parallelism of this digit to its fellows, are features that imply absence of powers of divarication and opposition. Its movements would seem to have been limited to those of simple flexion and extension in line with the other digits. In the remaining digits-sub equal in length and breadth-there is an even greater want of coaptation between the prominently convex heads of the metacarpals and the almost flat, articular surfaces of the bases of the proximal phalanges, which reveals a similar want

---

*Foss. Mammals of Australia, p 508

of coherent strength and similar limitations to movement. The considerable encroachment, palmad, of the articular surfaces of the distal ends of the proximal and, to a less extent, of the middle phalanges indicates, for these joints, either the habitual use of movements of flexion and extension or the persistent maintenance of the former position. In a foot examined *in situ* at Callabonna it was, indeed, noted that the digits were in a, condition of extreme flexion. The only digital joints of which the opposing surfaces can be said to interlock, to any degree, are those between the middle and ungual segments. The latter, in form, stand midway between the depressed, and but slightly curved, ungual phalanges of the wombat and the sickle-shaped and somewhat compressed elements of the kangaroo. The free provision for vascular supply would seem to be in excess of the requirements of claws for which, judging from their size and the strength of their structuml connections, there could have been but limited use.

Digits of this character would have been wholly indequate either for fossorial or offensive purposes, and if, as indicated by the diagnosis of Professor Radlkofer, of Munich, to whom, through the instrumentality of the late Baroll von Mueller, the remains of the food (or excrement) were sent for examination, the diet of Diprotodon consisted uf small stems and twigs belonging, chiefly, to the order Salsolaceae, or to the allied orders Amarantaceae or Nyctagineae, none of the members of which are known to have attained in Australia a height greater than that of shrubs, it would seem as if: for the purpose of obtaining these, the assistance of prehensile powers would not have been necessary in a beast of so great a size. It is permissible to speculate whether the chief use of the digits over and above their limited share in locomotion may not have been to effect the necessary manipulations for the transfer of the new-born young to the pouch; and it may be that the limited efficiency of the digits were rendered more efficient by some amount of power of pronation and suplsnation of the manus, which would appear to have been permitted by the characters of the superior radio-ulnar articulation.

In the pes, the astragalus shows the depression characteristic of this bone in the Marsupialia generally; but the head, on the other hand, in its prominence and semi-globular symmetry, shows an exceptional development for members of this class, which may be contrasted with the depressed characters of this part of the bone in Phalangista and Phascolomys.

From the astragalus of Macropus, that of Diprotodon differs entirely in character, and while it is stated that the latter most nearly resembles this bone in Phalangista,* it yet differs considerably not only in the character of the head, as just mentioned, but also in the remarkable flatness of the tibial surface, in the, usual, absence of any extension uf the tibial articular surface to the inner side, as well as in the feature next to be mentioned. The (when viewed from the inner side) obtusely angular process into which the middle of the inner border of the tibial surface is raised (pls. XL, figs. 1, 3, 4, B) recalls a somewhat similar

B.M. Cat. Foss. Mamm., Part V., 1887, p 184 (Lydekker) feature in the astragalus of Megatherium; and it is also stated, in the same communication, that this character is "common to all the extinct Megatherioids hitherto discovered."# As in the Megatherium, this pivot-like prominence is received, mortice fashion, into a notch which excavates the internal border of the lower end of the tibia in the region usually produced into the internal malleolar process. Thus, in place of a tibial process which, by its position, can serve the mechanical purpose of opposing displacement inwards of the astragalus and, with this, of the rest of the foot, we have in Diprotodon an astragalar process which would tend to check: displacement of the tibia in the same, and of the foot in the opposite, direction. In view of the internal malleolar deficiency, of the extreme flatness of the two opposing surfaces in the ankle joint-tibial and astragalar-and of the inward slope of the latter, this provision as it exists appears to add materially to the security of the joint.||.

The marked degree of inflexion which characterises the fulcral portion of the calcaneum of Diprotodon exists, also, in Phalangista and Phascolomys, but in the form of this part, ai:i indeed of the whole bone in the fossil, comparison lies rathel' with the former of the living types. In Macropus no such inflection exists either in the fulcral portion or in the remainder of the bone. If the hind foot of Phascolomys be so placed that the digits lie as nearly as possib1e in a horizontal plane, the proximal articular surface of the calcaneum slopes so steeply in wards that it approaches a vertical position. In the similarly placed foot of Phalangista the slope is much less steep, while in Diprotodon the inward slope of this surface is inconsiderable, and such inclination as does exist is mainly directed forwards. In both Phalangista and Phascolomys the articular surface for the cuboid is relatively larger than in Diprotodon.

The common feature of a large navicular contribution to the concavity for the head of the astragalus determines a consplscuous feature of general resemblance between this bone in Diprotodon, Phalangista, and Phascolomys; but in the extinct marsuplsal it is distinguished by the considerably greater relative size of the internal non-articular moiety as well as by the extreme obliquity of its position in the foot that has been pointed out. The former feature may have reference to the fact that, in the absence of an efficient hallux and in the weakness of the second and third metatarsals with their corresponding digits, this largely developed internal end of the navicular supplies a necessary point of support in a part of the

* Phil. Trans., vol. CXLIX" Part II., 1859, p. 815.

#*Ibid,* p. 821.

|| On this point we may remark that, in the setting up of our articulated foot, it is probable that we have given the astragalus a position in which this internal slope is somewhat in excess of what it should be. If, however, the plane of this surface is brought up nearer to the horizontal level-and the direction of the vertical axis of the tibia would indeed seem to require a slight change of position in this direction-such alteration in the astragalus also requires that a correlative tilt should be given to the calcaneum, on which the former so extensively rests and, with this, to the whole of the anterior part of the foot. The effect of such a combined tilt would be to elevate, to some extent, the inner side of the foot, and thus to throw the axis of superincumbent pressure more towards the outer side. This, when we regard the size and strength of the fifth metatarsal and the weakness of the inner toes, would seem to be that best fitted for the support of weight. The characters of the navicular and cuboid, nevertheless, as will be afterwards mentioned, are such as to suggest that-, as far forward as these hones at least., pressure is distributed to both sides of the foot, and, if there had been a difference of level between them, it might have been compensated for by a variable thickness of plantar pad. So far as the support of the body is concerned, the level of the two small inner digits would have mattered little.

foot that would, in its absence, be singularly lacking in resisting powers to superincumbent weight.

As regards the cuboid. it is to be noted that, while in Diprotodon this bone contributes materially to the formation of the large and symmetrical astragalar concavity, in Phascolomys it only articulates to a limited degree with the infero-external surface of the flattened anterior production that represents the head of the astragalus. A direct, though a very limited, articulation between the astragalus and the cuboid also exists in Macropus, but in Phalangista, on the other hand, the latter is excluded from direct contact with the former. The form of the bone in Diprotodon is, moreover, somewhat differentiated by the protuberance of its inner surface.

The coalescence of the meso- and ento-cuneiform, with the consequent reduction of the tarsal series to six bones, is, so far as we are aware, a feature found in no other marsupial. Exclusive of the diminutive meso-segment the considerable tranverse elongation of the ento-cuneiform-greatly in excess of that requisite for the articulation of the hallucial metatarsal-and the length of its surface of contact with the articular may indicate that, like the postero-internal part of the latter, it gives material support to the inner side of the foot. In respect of this elongated form and in the shape of the metatarsal articular surface a nearer approach to the conditions existing in Diprotodon is made by the ento-cuneiform of Phalangista than of Phascolomys.

The ecto-cuneiform, in its quadrilateral pyramidal shape, bears a general resemblance to the form of this bone in the two types so frequently mentioned in comparison, but differs in the small amount of articular surface assigned to the middle metatarsal, a feature which is in conformity with the small size of the latter; by far the larger part of its distal surface is in contact with the fourth metatarsal.

The fifth metatarsal repeats to a slightly more marked degree the peculiar features of the corresponding metacarpal. In Phascolomys and Phalangista the external surface of this bone also bears a conspicuous externally and posteriorly directed process, but in these it springs only from the proximal extremity, whereas in Diprotodon, though the production is most marked towards that end, it affects also more or less the whole of the outer side, In respect to form, the shorter, stouter metatarsal of Phascolomys is that which may be the more appropriately compared with the fossil.

The proximal phalanx of the fifth digit, like the corresponding segment of the manus, shows some degree of production of the external border, which is, however, here limited to the proximal end. The whole phalangeal series of this digit, though in length slightly, and in breadth considerably, exceeding the dimensions of the two inner digits, are yet small compared with the size of the animal.

In the remaining portions of the pes the degradation of the hind-foot, characteristic of the Diprotodont group of the Marsuplsalia and of the Peramelidae amongst the polyprotodonts, becomes evident in the attenuation of the second and third digits-particularly of the second-and, to a less marked degree, of the phalanges of the fourth, as well as in the reduction of the hallux to the metacarpal only. This degree of diminution in the size of the parts corresponding to the second and third digits, though relatively more considerable than that which obtains in Phascolomys, falls short of the symmetrical and almost filiform attenuation to which they are reduced in the Macroplsdae and Peramelidae.

In view of the syndactylism which is correlative with the reduction in size of the two digits in those marsupial families in which this condition exists, it is reasonable to suppose that it existed also in Diprotodon. In Phascolomys (mitchelli), though the slight and equal reduction of size only affects the second and third metatarsals and, to a less extent, their sequent phalanges, yet the integumentary syndactylism involves also, and to an extent equally with these, the fourth digit. The web, in fact, in all three toes extends to the articulations of the proximal and middle phalanges. Thus, when the small size of the phalangeal segments of the fourth digit in Diprotodon is regarded, it is not improbable that it, too, may have been involved in the syndactylism.

What has been said of the limitations of function imposed upon the manus by the collective feebleness of its digits, applies with even greater force to the pes, in which the feature of digital inefficiency is still more expressed either by extreme attenuation or, as in the hallux, by reduction of parts. Indeed it is difficult to imagine to what special use such digits as these might have been put.

CONCLUSIONS

Marsupial characters are evident in both the manus and pes of Diprotodon.

So far as the individual constituent bones are concerned they present resemblances to their homologous parts in both the Phalangeridae and the Phascolomyidae, but the approximation to the former is, on the whole, greater than to the latter.

On the other hand, regarding the feet as a whole, they, in their shape and proportions as well as in the character and degree of the attenuation of the second and third digits of the pes, are more readily comparable to these members in the Phascolomyidae.

With the more specialised pes of the Macropodidae comparison of that of Diprotodon yields scarcely any points of resemblance except in so far as the character of the degradation of the hind feet-similar in kind but varying in degree-affords evidence of the marsupial nature of both.

Thus the conclusions as to the generalised characters of Diprotodon, which have been reached through other parts of the skeleton, are confirmed by the structure of the feet.

The comparison that has been noted between a feature in the astragalus of Diprotodon and in that of Megatherium is interesting under the analogies, to which Owen has alluded, that may be drawn between the mode and conditions of existence of these edentate and marsupial giants, but as we are, in this communication, dealing only with a limited portion of the skeleton, we abstain from inquiry into what, if any, significance the structural point of resemblance in question may have. In this connection we may, however, take the opportunity of stating-as we are not aware that the fact has yet been recorded-that the characters of the, comparatively, short and, relatively, slender tail of Diprotodon excludes, even if no other evidence should exist, the possibility that it could have served any such purpose of support as that attributed to, and doubtless performed by, this ponderous appendage of the Megatherium.

POSTSCRIPT

Since the above was printed we have had occasion, in the course of investigations as to the nature of some fossil reptilian remains, to refer to a communication by Owen to the Royal Society [Phil. Trans., vol. CLXXVII. (1886), p. 327, "Description of Fossil Remains, including the Foot- bones of *Megalania prisca"*]. Therein we find, described and represented in accompanying plates (Nos. XIV. and XV.), figures of certain foot-bones described in the text to Megalania, which are unmistakably those of *Diprotodon australis.* Thus, on plate XIV., the figures are those of a right fifth metacarpal; on plate *XV.* figs. 10-12 are those of a left third metacarpal; figs. 13-15 of a right second metatarsal; figs. 16 and 17 of a proximal phalanx of the right fifth digit of the pes, and figs. 18 and 19 of an ungual phalanx of the manus of rather large size.

It further appears, from a " Note on the Extinct Reptilian Genera, Megalania, *Owen,* and:Meiolania, *Owen,"* by A. Smith Woodward,*, that the marsupial nature of foot-bones precisely similar to those described by Owen, as above, has been recognised by Lydekker who, it is stated, has included them in the British Museum Catalogue of Fossil Mammalia (Part V., 1887, p. 169) amongst a group of foot-bones assigned to uncertain members of the Nototheriidae and Phascolomyidae.

*Annals and Magazine of Natural History, Sixth Series, vol 1 pp 85-89

EXPLANATION OF PLATE I

ARTICULATED RIGHT MANUS (p 6)

Dorsal aspect *half size*

Letter references

C Cuneiform. The letter stands on its ulnar concavity.

M Magnum.

P Pisiform. The letter stands on its ulnar concavity.

Sc Scaphoid. The letters stand on its radial articular surface.

S Scaphoidal sesamoid.

T Trapezium.

Tv Trapezoid.

U Unciform.

The Roman numerals 1.- V. are placed on the metacarpals, 1. being that of the pollex, and the phalanges succeed in serial order.

NOTE.-The cuneiform, being a substituted bone, is not a perfect fit for the unciform, consequently the pisiform is thrown a little out of position. Thus the lower part of the antero-internal region of the latter does not quite touch the unciform, which it should do. It also escaped observation, when the photograph was being taken, that the scaphoid had slipped a little towards the radial side, leaving exposed a portion of the scaphoidal articular surface of the unciform

PLATE I

EXPLANATION OF PLATE II

SCAPHOID AND SCAPHOIDAL SESAMOID (p 6)

All figures represent right-sided bones and are of natural size.

Fig 1. Scaphoid, radial surface.

Fig 2. Scaphoid, inferior surface.

Fig 3. Scaphoid, anterior surface.

Fig 4. Scaphoid, posterior surface.

Fig 5. Scaphoidal sesamoid, internal aspect.

Fig 6. The same seen in profile, the concavity representing the aspect of application to the Scaphoid.

LETTER REFERENCES

A, A Oblique groove, delimiting articular and non-articular moieties.

B Radial articular surface.

C Angular projection of internal surface.

D Facet for radial styloid process.

E Sesamoidal surface.

F Articular surface for the Trapezium.

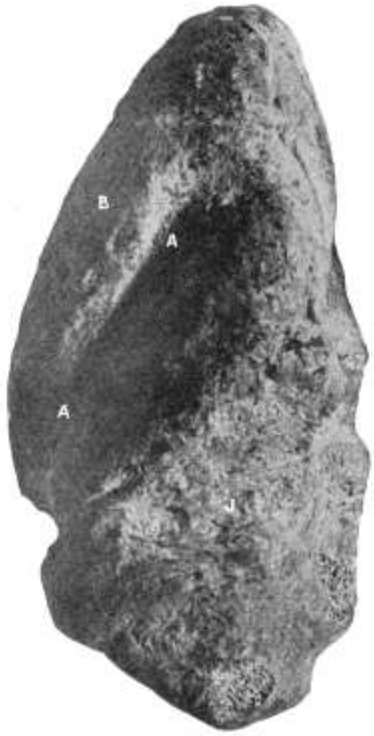
G Articular surface for the Unciform.

H Articular surface for the Magnum.

I Articular surface for the Trapezoid.

J Shallow trough or depression on inner part of posterior surface. This in the figure (4) is scarcely evident.

1



4

2

5

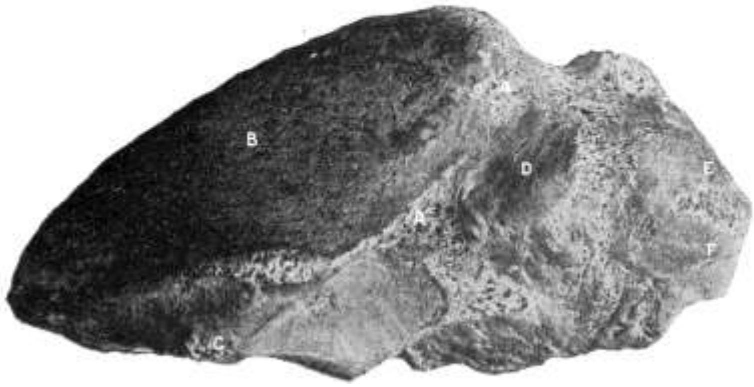


PLATE II

EXPLANATION OF PLATE III

CUNEIFORM AND PISIFORM (pp 8 and 9)

All figures represent right sided bones ansd are of natural size

Fig 1. Cuneiform, proximal or ulnar surface.

Fig 2. Cuneiform, antero-internal surface.

Fig 3. Cuneiform, dorsal surface with facets for Ulna and Unciform in perspective.

LETTER REFERENCES TO FIGS 1-3

A Ulnar concavity.

B Facet for Pisiform.

C Facet for Unciform.

D Line of meeting of Ulnar and Unciform facets.

E Dorsal surface.

Fig 4 Pisiform, anterior surface.

Fig 5.Pisiform, dorsal surface.

LETTER REFERENCES TO FIGS. 4 AND 5, AND TO F'IGS. 1 AND 2 OF PLATE IV.

A Ulnar concavity.

B and C Outer and inner borders of the above.

D Region of contact with Unciform.

E Facet for Cuneiform.

F, F Rugose ridge on palmar surface.

G Elevation on dorsal surface.

R and I Anterior and posterior elevations of internal surface seen in profile.

J and K Anterior and posterior elevations on external surface seen in perspective and foreshortened.

L, L & M, M Rugose ridges bounding dorsal and palmar surfaces posteriorly and externally.

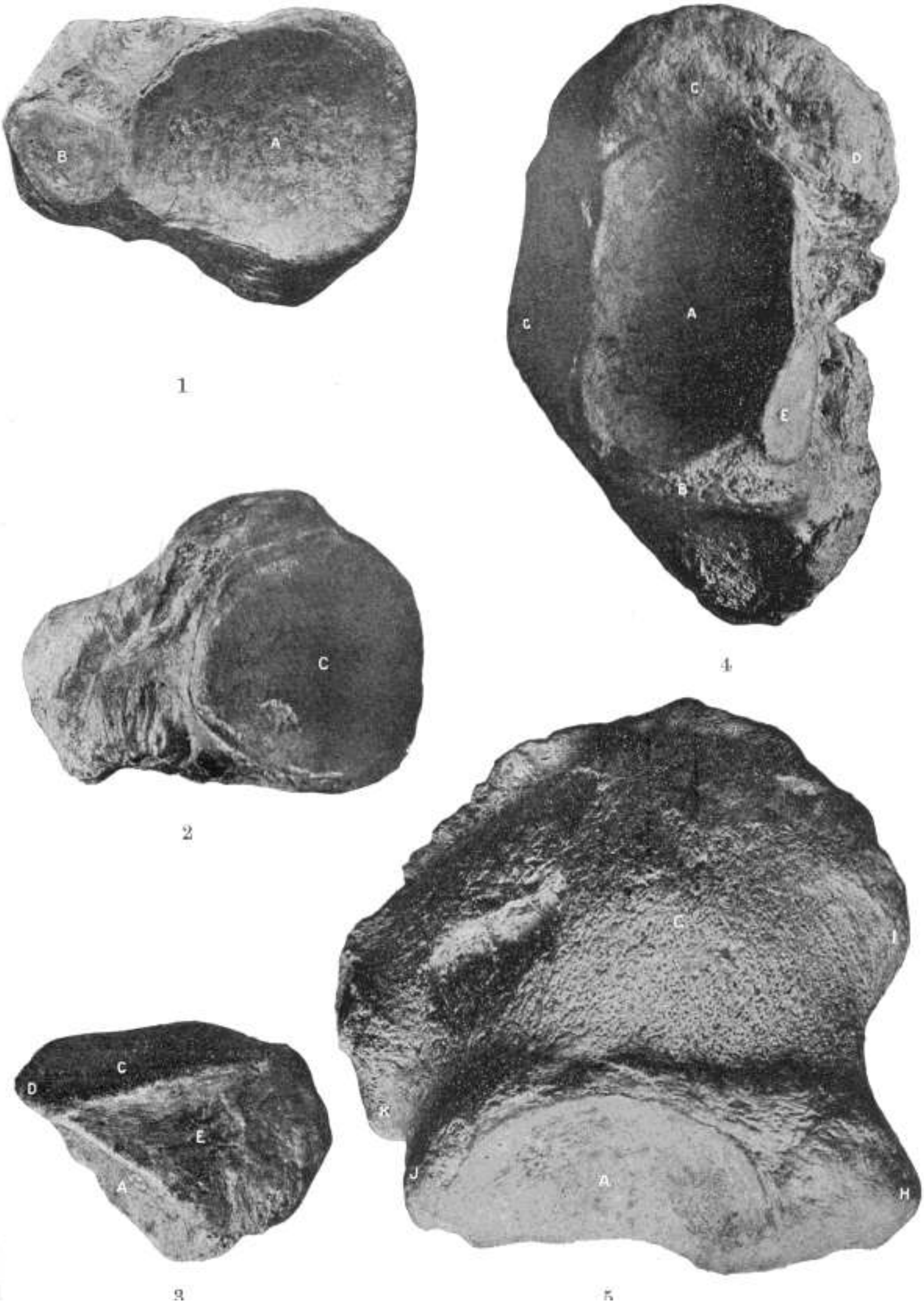


PLATE III

EXPLANATION OF PLATE IV

PISIFORM AND TRAPEZIUM (pp 9 and 10)

All figures represent right-sided bones and are of natural size.

Fig. 1. Pisiform, palmar surface.

Fig 2. Pisiform, postero-external aspect.

FOR LETTER REFERENCES TO FIGS. 1 AND 2 *VIDE* EXPLANATION OF PLATE III, FIGS. 4 AND 5.

Fig 3. Trapezium, trapezoidal or postero-external surface.

Fig 4. Trapezium, proximal surface.

Fig 5. Trapezium, dorsal surface.

Fig 6. Trapezium, metacarpal surface.

LETTER REFERENCES TO FIGS 3-6

A Facet for Trapezoid.

B Facet for Scaphoid; the facet lies between B and C.

C Tuberosity on dorsal surface.

D Facet for first metacarpal.

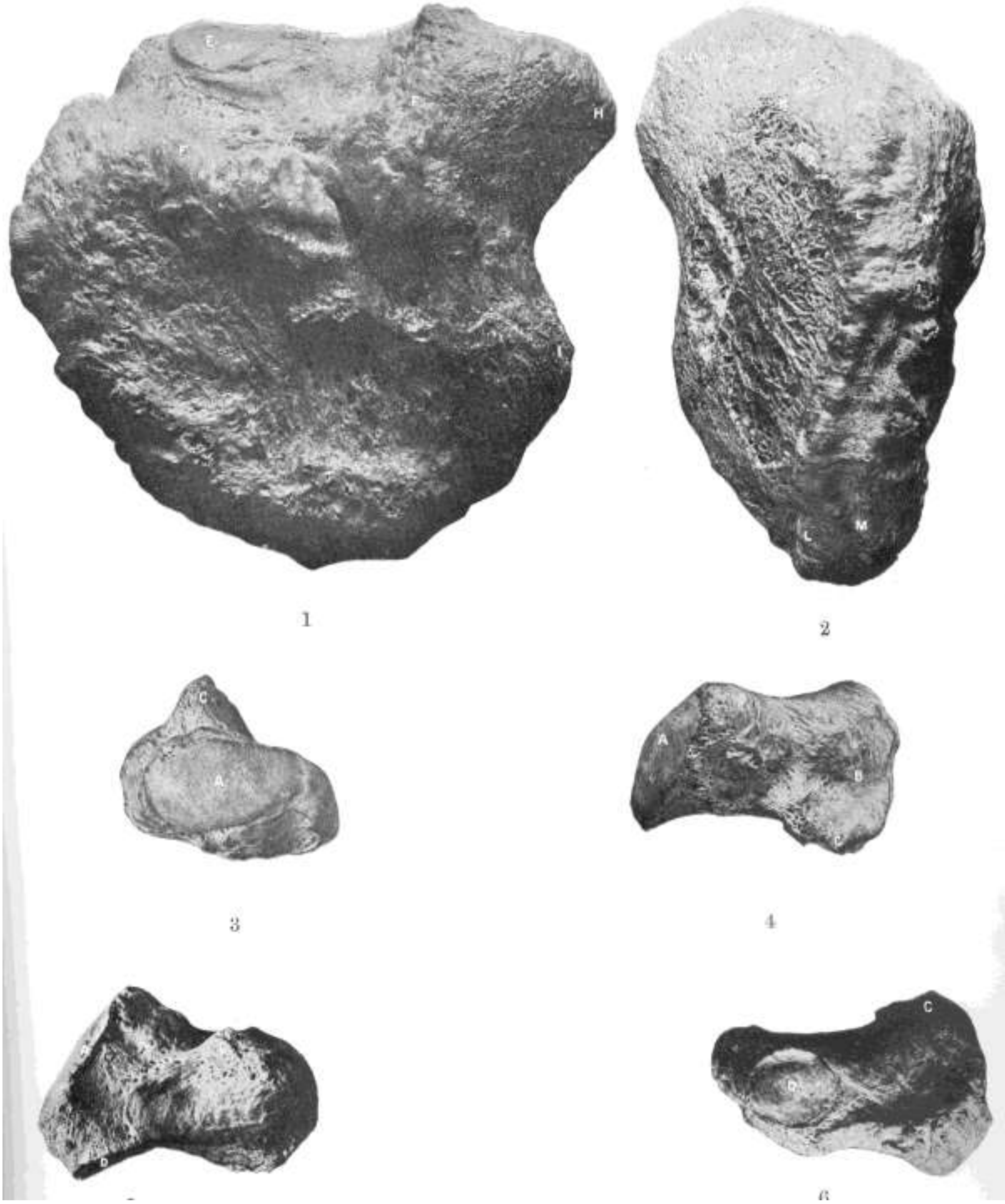


PLATE IV

EXPLANATION OF PLATE V

TRAPEZOID AND OS MAGNUM (pp 11 and 12)

All figures represent right-sided bones and are of natural size.

Fig 1. Trapezoid scaphoidal surface (postero-internal).

Fig 2. Trapezoid, alltero-external surface.

Fig 3. Trapezoid, facet for Trapezium (antero-internal surface); the inferior angle is slightly damaged.

Fig 4. Trapezoid, dorsal surface.

LETTER REFERENCE FOR FIGS 1 -4

A Facet for Scaphoid.

B Facet for Magnum.

C Vacet for Second Metacarpal.

D Facet for Trapezium; except in fig. 1, where D stands on the dorsal surface.

E Dorsal surface.

F Apex of pyramid (vide text).

G and H Stand on the dorsal margins of the magnal and metacarpal facets respectively.

Fig 5. Magnum, dorsal surface with parts of internal and external aspects in perspective.

Fig 6. Magnum, distal surface.

Fig 7. Magnum, internal surface.

Fig 8. Magnum, external surface.

LETTER REFERENCE FOR FIGS 5-8

A, A Facet for scaphoid

B Facet for Trapezoid

C Palmar ridge

D, F, E (and F, E) Facet for Unciform

G, G, G, G Facet for Third Metacarpal

H, H Facet, or facets, for Second Metacarpal

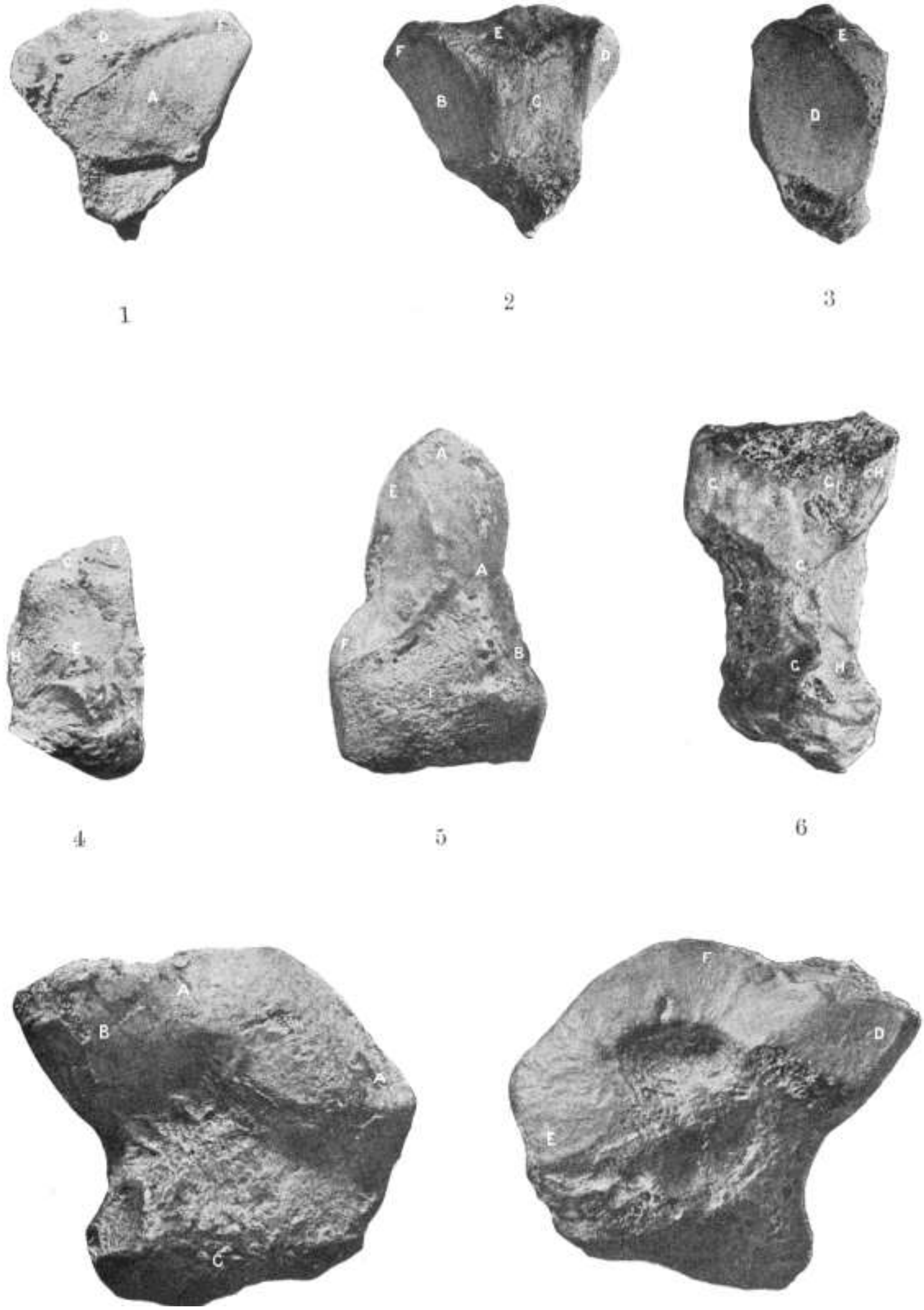


PLATE V

EXPLANATION OF PLATE VI

UNCIFORM (p. 13)

All figures represent right sided bones and are of natural size

Fig. 1. Scaphoidal surface.

Fig 2. Postero-external surface.

Fig 3. Digital surface, showing also part of the palmar surface in perspective.

Fig 4. Antero-internal surface.

LETTER REFERENCES

A Facet for Scaphoid.

B Facet for Cuneiform.

C Surface against which the Pisiform abuts. From a little above A in fig. 2 to C the articular surface enters into the formation of the ulnar cup.

D Groove below Cuneiform facet.

E, F, E Articular surface for the Magnum.

G Facet for Fifth Metacarpal.

H Facet for Fourth Metacarpal.

I Palmar border of distal surface.

J Dorsal surface.

K Palmar surface seen in perspective.

1

2

3

4

PLATE VI

EXPLANATION OF PLATE VII

METACARPAL AND PHALANGES (pp 14 and 18)

Dorsal Aspect

All figures represent right-sided bones and are of natural size.

The Roman numerals placed on the Metacarpals indicate the ordinal rank of the digits, the Phalanges succeeding in serial order.

LETTER REFERENCES TO PLATES VII., VIII., and IX

A First Metacarpal, facet for Trapezium.

B, B Second Metacarpal, facet for Magnum.

C Second Metacarpal, facet for Trapezoid.

D Second Metacarpal, facet for Third Metacarpal.

E Second Metacarpal, tuberosity on dorsal surface.

F Second Metacarpal, production inwards of distal end.

G Third Metacarpal, facet for Magnum.

H Third Metacarpal, notch at dorsal part of proximal surface.

I Third Metacarpal, facet for Second Metacarpal.

J Third Metacarpal, facet for Fourth Metacarpal.

K Third Metacarpal, tuberosity of dorsal and inner surface.

L Fourth Metacarpal, facet for Unciform.

M Fourth Metacarpal, facet for Third Metacarpal.

N Fifth Metacarpal, facet for Unciform.

O Fifth Metacarpal, facet for Fourth Metacarpal.

P Fifth Metacarpal, tuberosity on inner surface.

Q Fifth Metacarpal, notch on outer border.

R Fifth Metacarpal, smooth tuberosity on outer border.

S Fifth Metacarpal, tuberosity on outer border near proximo-internal angle.

T First Metacarpal, internal tuberosity.

V Second Metacarpal, site of occasional facet on inner surface of Second Metacarpal.

PLATE VII

PLATE VIII

METACARPALS AND PHALANGES (pp 14 and 18)

Internal Aspect

For explanation and letter reference see pl VII

PLATE VIII

PLATE IX

METACARPALS AND PHALANGES
Proximal Aspect

All figures represent right-sided bones and are of natural size.

In this plate the Roman numerals, indicating the ordinal rank of the digits, are placed on the proximal surfaces of the first series of Phalanges, the corresponding Metacarpals forming the lowest horizontal row of figures. All the bones are arranged so that the dorsal borders are uppermost.

For letter references see pl VII

PLATE IX

PLATE IX

EXPLANATION OF PLATE X

ARTICULATED RIGHT PES

DORSAL ASPECT, *half size*

Fig. 1. With the Astragalus in. position.

Fig 2. With the Astragalus removed.

LETTER REFERENCE

A Astragalus. The letter stands on its tibial surface

C Calcaneum. The letter stands on its fulcral portion

CB Cuboid.

E Ento-cuneiform.

EC Ecto-cuneiform.

N Navicular.

R The calcaneal,

S The cuboidal, and

T The navicular ,contributions to the cup for the head of the Astragalus.

The Roman numerals are placed on the Metacarpals, T. being that of the Hallux. The Phalanges succeed in serial order.

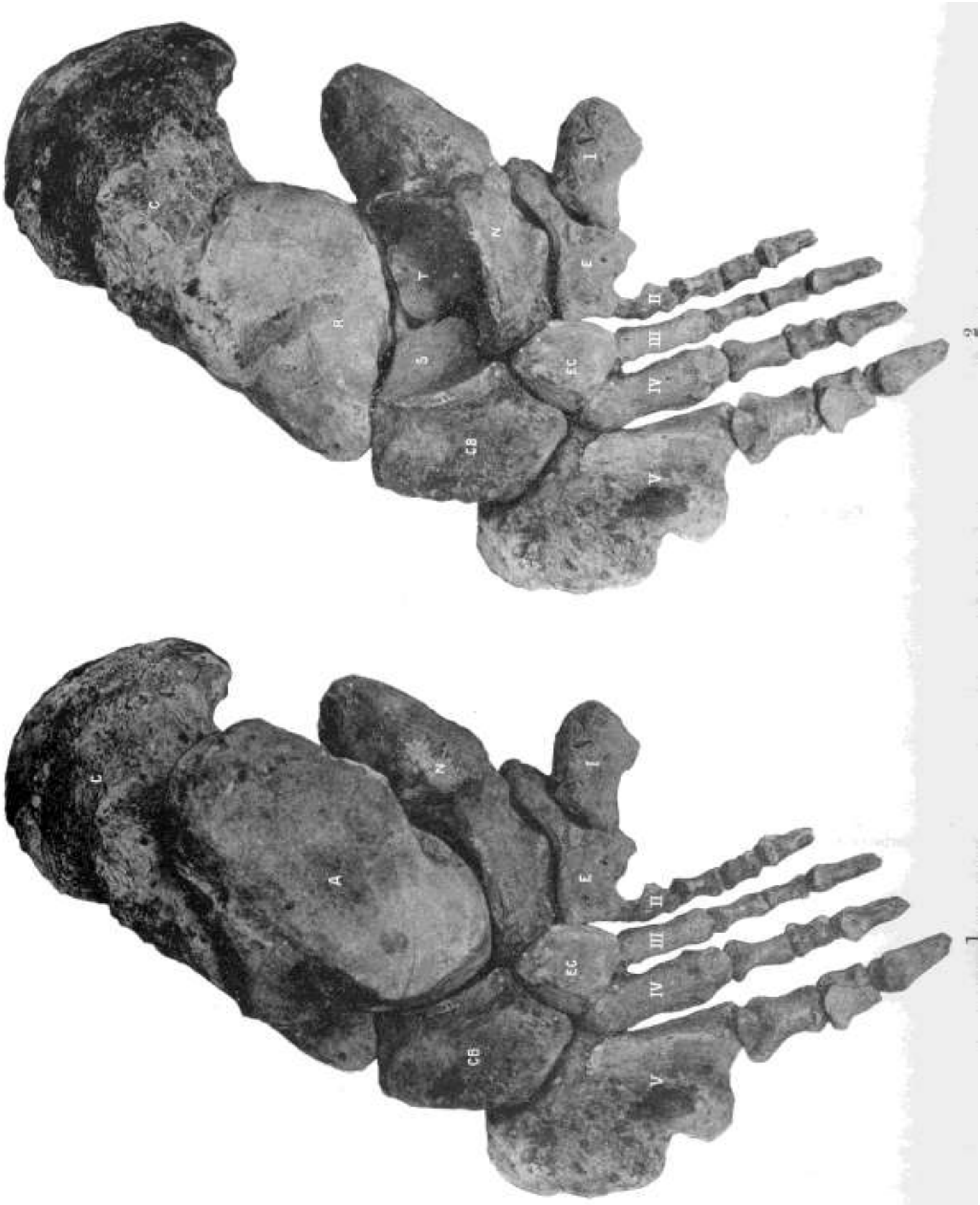


PLATE X

EXPLANATION OF PLATE XI

ASTRAGALUS (p. 22)

All figures represent right-sided bones and are of natural size.

Fig 1. Astralagus, tibial surface.

Fig 2. Astragalus, distal surface.

Fig 3. Astragalus, internal surface.

Fig 4. Astragalus, external surface.

LETTER REFERENCES TO PLATE XV AND TO FIG 1 OF PLATE XII

A Tibial surface of Astragalus.

B Angular process of internal border of tibial surface.

C Fibular articular tract.

D Tract for Os Pyramidale.

E Articular surface of head,

F Upper, and

G Lower depressions on internal surface.

H Articular tract for Calcaneum,

J Non-articular tract posterior to tibial surface.

K Posterior surface.

PLATE XI

EXPLANATION OF PLATE XII

ASTRAGALUS AND CUBOID (pp. 22 and 24

All figures represent right sided bones and are of natural size.

Fig. 1. Astragalus, anterior aspect.

FOR LETTER REFERENCES TO FIG. 1, *vide* PREVIOUS PLATE.

Fig 2. Cuboid, postero-internal aspect.

Fig 3. Cuboid, antero-internal aspect, showing also distal surface (G, H) in perspective.

Fig 4. Cuboid, distal aspect.

Fig 5. Cuboid, dorsal surface.

LETTER REFERENCES TO FIGS. 2-5.

A Concavity for Astragalus.

B Convexity for Calcaneum.

C, C Superior part of Navicular facet.

D Plantar extension of the above.

E Upper facet for Ecto-cuneiform.

F Lower facet for Ecto-cuneiform.

G Articular surface for Fifth Metatarsal.

H Articular surface for Fourth Metatarsal.

J Tuberosity at plantar border of distal surface

K Dorsal surface.

1

2

3

PLATE XII

EXPLANATION OF PLATE XIII

CALCANEUM

All figures represent right-sided bones and are of natural size.

Fig. 1. Calcaneum, dorsal surface.

Fig 2. Calcaneum, inner surface.

LETTER REFERENCE

A, A, A Articular surface for Astragalus.

B Deep depression for ligamentous attachment.

C Concavity for Cuboid.

D Stands at the superior and inner margin of the above concavity.

E Dorsal surface of fulcral portion.

F, F Posterior surface seen in perspective.

PLATE XIII

EXPLANATION OF PLATE XIV

NAVICULAR (pp. 25)

All figures represent right-sided bones and are of natural size.

Fig 1. Navicular, proximal aspect.

Fig 2. Navicular, distal aspect.

Fig 3. Navicular, antero-internal aspect.

Fig 4. Navicular, external (antero-external)

LETTER REFERENCES

A Concavity for Astragalus.

B Apex of re-entrant angle of antero-external margin of the same.

C Superior, and

D Inferior arms of articular surface for the Cuboid.

E Facet for Ecto·cuneiforrn.

F, F Facet for Ento-cuneiform.

G Rugose tract on antero-inferior surface.

PLATE XIV

EXPLANATION OF PLATE XV

ENTO-CUNEIFORM AND ECTO-CUNEIFORM (pp 26 and 27)

All figures represent right-sided bones and are of natural size.

Fig 1. Ento-cuneiform proxima1 aspect.

Fig 2. Ento-cuneiform, distal aspect.

Fig 3. Ento-cuneiform, plantar aspect.

LETTER REFERENCES TO FIGS. 1-3.

A Dorsal orifice of foramen perforans, indicating line of union of meso and Ento-cuneiform.

B Groove on facet for Navicular corresponding to same line.

C The Meso-cuneiform portion of facet. for Navicular.

C, B, D The whole facet for Navicular. [In fig. 2, by an error, the same letter (D) has been made to indicate the dorsal surface seen in perspective.]

E Facet for Ecto-cuneiform.

F Occasional facet for Ecto-cuneiform (or Second Metatarsal 1).

G Facet for First Metatarsal.

H Facet for Second Metatarsal.

K Plantar surface.

Fig 4. Ecto-cuneiform, antero-internal surface, showing facet for Navicular (A) in perspective.

Fig 5. Ecto-cuneiform, postero-external or cuboidal aspect.

Fig 6. Ecto·cuneiform, distal surface.

Fig 7. Ecto-cuneiform, dorsal surface.

LETTER REFERENCES TO FIGS 4-7

A Facet for Navicular.

B Stands near apex of bone on a small raised non-articular tract.

C Upper facet for Cuboid.

D Lower facet for Cuboid. [This refers to the lower D in fig. 5; the upper D in the same figure marks the dorsal surface of the bone as it does, also, in figs. 4 and 7.]

E Facet for Ento-cuneiform.

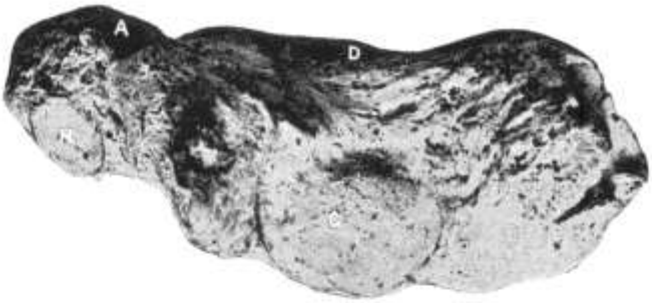
F, F Facet for Fourth Metatarsal.

G Facet for Third Metatarsal.

H Dorsal surface, the anterior border being lowermost on the page.

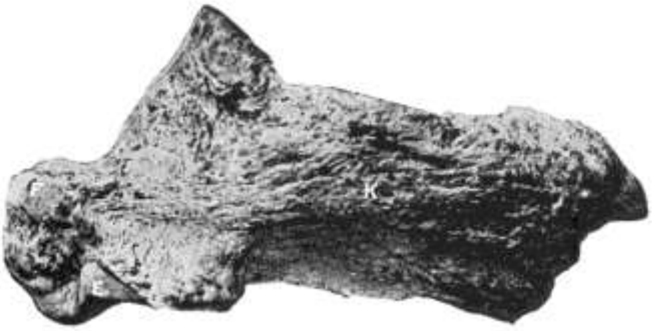
1

4



2

5



3

7

6

PLATE XV

EXPLANATION OF PLATE XVI

METATARSALS AND PHALANGES (pp 27 and 30

DORSAL ASPECT.

All figures represent right-sided bones and are of natural size.

The Roman numerals, placed on the Metatarsals, indicate the ordinal rank of the digits, the Phalanges succeeding in serial order.
Besides the complete series of Metatarsals and Phalanges which, together, constitute fig. 1 of this plate, there are shown, also, a Proximal Phalanx of the fifth digit of unusually large size (fig. 3), and a Second Metatarsal, probably, more normal than that belonging to the series (fig. 2).

LETTER REFERENCES TO PLATES XVI., XVII., AND XVIII.

A First Metatarsal, facet for Ento-cuneiform.

B Second Metatarsal, facet for Meso-segment of the same.

C Second Metatarsal, articular surface for Proximal Phalanx.

D Facet on Second Metatarsal, separately figured, for Third Metatarsal.

E Third Metatarsal, facet for Ecto-cuneiform.

F Third Metatarsal, facet for Second Metatarsal.

G Fourth metatarsal, facet for Cuboid.

H, H Fourth Metatarsa1, facet for Ecto-cuneitorm.

J Fifth Metatarsal, proximal articular surface.

K Fifth Metatarsal, facet for Fourth Metatarsal.

L, L Fifth Metatarsal, line of epiphysial junction.

M Proximal facets of First Phalanges.

N Os Pyramidale. tibial surface.

O Os Pyramidale, fibular surface.

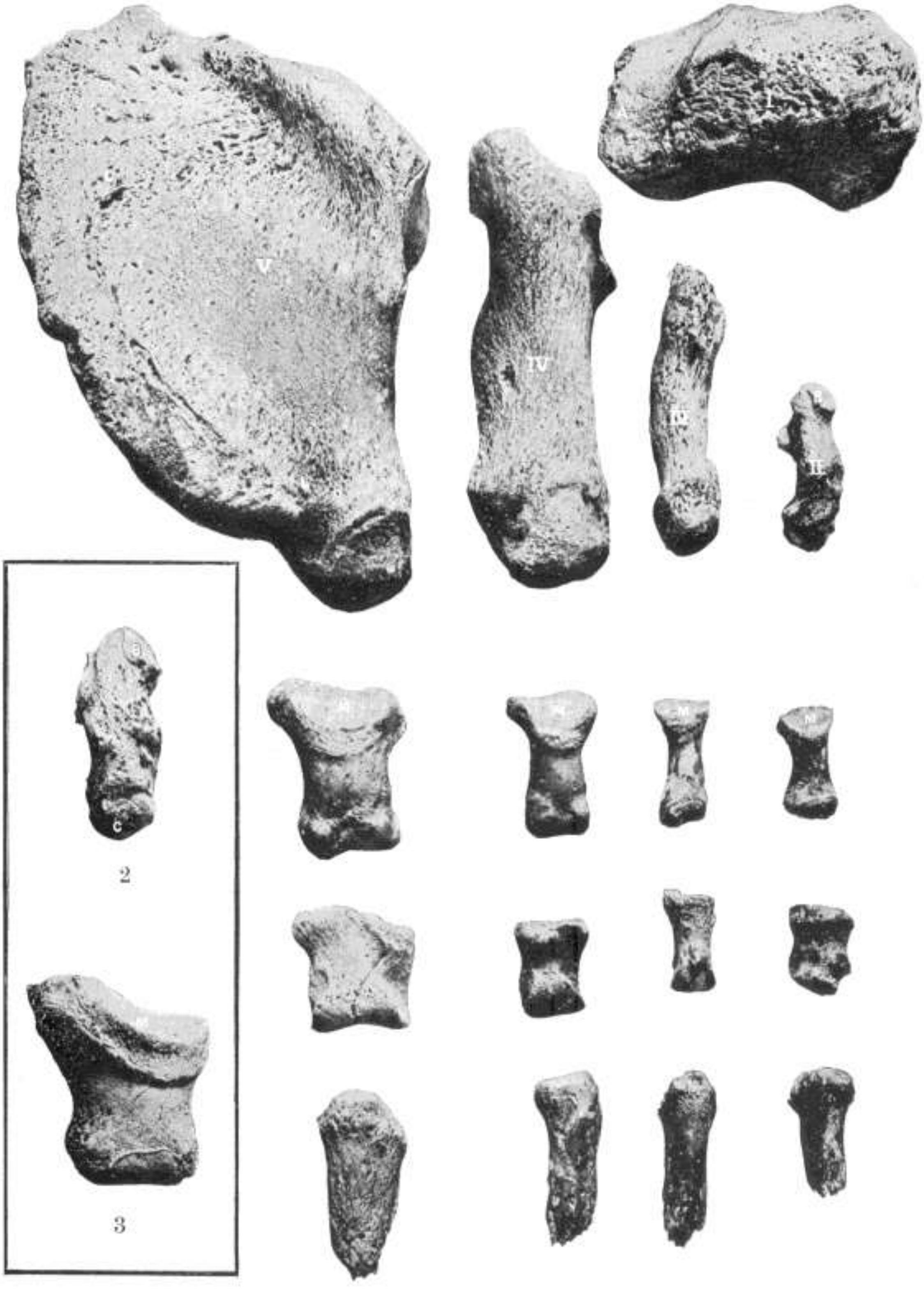


PLATE XVI

PLATE XVII

METATARSALS AND PHALANGES (pp> 27and 30)

All figures represent right-sided bones and are of natural size.

The Roman numerals placed on the Metatarsals indicate the ordinal rank of the digits, the Phalanges succeeding in serial order.

Figs. 2 and 3 represent, respectively, the outer and inner surfaces of the same separate (Second) Metatarsal which appears, as fig. 2, in p1. XVI.; the other figures collectively form fig. 1.

For letter references see plate XVI

1
PLATE XVII

PLATE XVIII

METATARSALS AND PHALANGES

PROXIMAL ASPECT

All figures represent right-sided bones and are of natural size.

In this plate the Roman numerals, indicating the ordinal rank of the digits, are placed on the proximal surfaces of the First series of Phalanges. The corresponding Metatarsals thus form the lowest horizontal row. All the bones are angled so that the dorsal surfaces are uppermost in the figures.

Fig. 2 represents a right Os Pyramidale, which belonged to the tarsus of the articulated foot; the rest of the plate forms fig. 1.

For letter references see plate XVI

Ernest Gall, Photo Illustrator,
11, Alma Chambers, Adelaide.

PLATE XVIII