XV. Polacanthus Foxii, *a large undescribed Dinosaur from the Wealden Formation in the Isle of Wight.*

By J. W. Hulke, *F.R.S.*

Received January 3,—Read January 27, 1881.

[Plates 70–76.]

For the opportunity of studying the remains described in this note I am indebted to the courtesy of the Rev. W. Fox, of Brixton, Isle of Wight, who last autumn gave me free access to his rich collection of fossils obtained in that locality.

Much shattered by being very hastily dug out, and since much damaged by the accidental breakages and the dissociations scarcely avoidable in the absence of a suitable place for their safe-keeping, there is risk of these remains becoming before long lost to the palæontologist. In view of this not improbable eventuality I venture to offer to the Royal Society these notes, in writing which I have been reminded that it was to this Society the late Dr. G. A. Mantell, now more than fifty years since, communicated his first discoveries of Iguanodont and Hylæosaurian remains.

The remains of *Polacanthus* were found by Mr. Fox in 1865 in a bed of blue shaly clay, which occurs near the middle of the cliff, a short distance east of Barne's Chine. The bed is easily recognisable by the large quantities of lignite which it contains.

Professor R. Owen, to whom Mr. Fox showed some of these fossils soon after their discovery, suggested for the animal indicated by them the name *Polacanthus*—many-spined—*P. Foxii*, and this name Mr. Fox adopted in an account of his discovery read by him at the next meeting of the British Association. A brief notice of the discovery with a rude woodcut also appeared about the same time in the "Illustrated London News." Both these communications have only the value of preliminary notices by persons without anatomical training, and no description of the fossils sufficient for the use of palæontologists has yet appeared.

Mr. Fox's MS., read at the meeting of the British Association, cannot now be found, and his paper does not appear in the "Reports." An abstract which I made of it in 1869 gives the following list of the parts he believed he had secured.

"Sacrum and pelvis; 7 lumbar, 7 anterior dorsal vertebræ with their ribs; 20 caudal vertebræ; 2 femora; 1 tibia with fibula; 3 metatarsals, phalanges, and 3 unguals; 20 to 30 large dermal spines, and as many scutes."

The scattered remains which last autumn I succeeded in bringing together again do

not quite agree with these numbers; the vertebræ, foot-bones, and dermal spines are fewer, and I was not able to identify any portions of Ilium, Ischium, or Pubis.

Vertebral column.—This is now represented by 11 præsacral, five sacral, and 15 postsacral or caudal vertebræ.

The 11 præsacral vertebræ comprise six disconnected and five anchylosed in a continuous series.

Of the six disconnected vertebræ three are fairly complete (Plate 70, figs. 1, 2). The form of the centrum is cylindroid; it is long relatively to its breadth, slightly constricted at its middle and expanded at its articular ends, which are plane or very slightly concave, the concavity of the posterior surface being most evident. The antero-posterior extent of the neurapophyses at their attachment to the centrum nearly equals the length of this latter. Their anterior margin rises nearly vertically from the centrum, whilst their posterior margin has a strong forward slant. The spinous processes of all the præsacral vertebræ are broken off and missing. The transverse processes in this series show a double costal articulation. In the level of the crown of the arch is a large, conspicuous, capitular, costal facet borne jointly by the arch and root of transverse process. It is directed outwards, and against it in two instances the rib-head, of an expanded discoid form, still abuts. Above this, the process, slender and trihedral in cross-section, is prolonged outwards and upwards above the rib-neck. It bore at its free end, as is shown by detached pieces, an articular surface for the tubercle of the rib. The length of the vertebral centrum (represented in Plate 70, figs. 1, 2) is 75 millims.; the horizontal diameter at the articular ends is 52 millims., and the vertical diameter here 51 millims.; and the horizontal diameter at the middle of the centrum is 35 millims. The double costal articulation places these six disconnected vertebræ in the front of the trunk. Between them and the five anchylosed vertebræ several are doubtless missing, since these last are demonstrated to belong to the loins by the anchylosis of the hindmost of the series to the first sacral centrum.

The lumbar centra (Plate 71, fig. 1) have a more attenuate form than that of those referred to the front of the chest. Their lateral surfaces slope inwards and meet somewhat angularly below. This is very apparent in the second in the chain. The spinous and transverse processes of all are broken off and missing.

The average length of the centrum in this series is 75 millims., the horizontal diameter at the middle is 33 millims., 30 millims., 30 millims., 34 millims.; and that of the articular ends is 40 millims., 37 millims., 36 millims., 50 millims.

Sacrum (Plate 71, fig. 1).—This has the usual dinosaurian structure; it consists of a chain of five anchylosed centra much larger than the slender lumbar centra. Accidental cross-sections made by fractures show the form of the centrum to be remarkably depressed (fig. 2); it is, however, not improbable that this great excess of the horizontal over the vertical diameter may have been increased by pressure. These diameters are in the second centrum 70 millims. and 25 millims. respectively. The

under surface of the centrum is cylindroid; in the three foremost centra a shallow median groove indents it longitudinally. The piers of the neural arches rest each on two centra, and the sacral nerves escaped from the vertebral canal across the middle of a centrum except the last nerve, which passed out intervertebrally between the last sacral and the first caudal vertebra. A stout lower transverse process stands out from the side of the sacrum along the line of junction of each two centra, and doubtless the outer ends of these processes coalesced in the usual looplike manner: all have been broken off, and are now missing. The upper transverse processes which project from the crown of the arch are small and inconspicuous; they form, with the expanded summit of a dwarfed spinous process, the support of a stout dermal armour to be presently described. Comparison of the following measurements of the sacral centra with those of the præsacral centra already given will make the greater bulk of the former very apparent.

Sacral centra.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Horizontal diameter at the articular ends . . .	*	87	87	87	87
,, ,, middle of centrum . . .	70	70	70	70†	82
Length of centrum	67	67	67	62	58

Post-sacral vertebræ (Plate 72, figs. 1, 2; Plate 73, figs. 1, 2; Plate 75, figs. 3, 4).—The 13 now remaining are certainly not a continuous series—many intermediate ones are missing; most are from the root of the tail.

The first caudal, known to be such by its exactly fitting the last sacral, differs from this most obviously by the centrum bearing entirely its own arch. It and those centra, which by their great size are referable to the root of the tail close to the sacrum, bear no chevron mark. These centra are short and wide; their articular ends are both gently concave, and they have a depressed heart-shaped contour. In one of the best preserved the horizontal diameter of the articular end is 100 millims., that of the anterior end being about 90 millims., whilst the vertical diameters of the same ends are 64 millims. and 61 millims., and the length of the centrum measured along its neural surface is 52 millims. At their middle these centra are much contracted. The transverse process stands off from the side of the centrum horizontally just below the line of the neurocentral suture. The arch is low; the spinous process has a strong backward slant; the post-zygapophyses are large and prominent. Other caudal vertebra smaller than those just described differ from them mainly in the presence of chevron marks and in the greater concavity of their articular ends. At least 13, probably about 17 or 18, of the vertebræ in the fore part of the tail had transverse processes; two smaller vertebræ, which by their very small size belonged to near the end of the tail, have a simple cylindroid figure; the processes have disappeared, and the arch is reduced to a tubular hoop (Plate 75, figs. 3, 4).

* Rather less than others.

† The numbers in this line, except the last, are approximate.

The osseous tissue of all the vertebræ is coarse, and the outer surface wants the closeness of texture and the smoothness so observable in Iguanodont bones. This textural difference serves to distinguish very mutilated pieces. It is not peculiar to this particular skeleton, for it is equally apparent in a thoracic vertebra which I dug a quarter of a mile to east of the place where this skeleton was discovered—a distance which makes it almost impossible that it should have ever formed part of it.

Ribs.—Many of these show a double vertebral articulation by head and tubercle. In those referable to the front of the chest, as has been already mentioned, the head of the rib is very swollen and the neck is relatively slender. These parts are wanting in all the disconnected ribs from this part of the chest, but they are fortunately preserved *in situ* upon three vertebræ (Plate 70, figs. 1 and 2). In this region the neck of the rib is short, and it joins the body of the rib in an almost uniform curve. In ribs referable to the middle of the trunk a very decided angle marks the junction of the tubercle and body (Plate 76, fig. 2). In all ribs with double vertebral articulation the neck is slender, and it is so compressed that the long diameter of its cross-section is vertical. Beyond the tubercle the upper border (here become outer) expands so widely as to deserve the term "surface," whilst the lower (here inner) border continues thin. This gives a triquetrous form and great strength to this part of the rib.

Limbs.—The femur (Plate 74) is remarkable for the largeness of its articular extremities and the slenderness of its shaft. Both ends are much damaged by pressure. My description is taken from the right, which is better preserved than the left. The proximal end bears at its inner angle a sessile sub-hemispherical head (*cap.*), external to which and nearly in the same level with it is a well-developed trochanter (*tr.m.*). The inner or posterior trochanter (fig. 2, *tr.i.*), characteristic of dinosauria, is also strongly developed; it is rather nearer to the proximal than the distal end of the bone. The knee condyles are very large; the inner is somewhat the larger of the two; a deep narrow groove separates them in front, and a wider, relatively shallow, depression divides them behind. The length of the right femur is 55·5 centims.; the diameter of the distal end across the condyles is 15·5 centims., and that of the proximal end is 18 centims. The diameters of the caput femoris are 9 centims. and 8·5 centims., and that of the middle of the shaft is 8 centims.

The Tibia (Plate 75, figs. 1, 2), the left one, is much shorter than the femur, being only 35 centims. long. It resembles the femur in the largeness of its joint ends and the slenderness of its shaft. The proximal end, distorted by pressure, shows obscurely a division of the articular surface into two parts answering to the femoral condyles (*cd.*), and a remarkably large præcnemial process (*prc.*). The distal end, flattened, is of the usual dinosaurian pattern, having a longer and narrower outer and a shorter and stouter inner division. When the bone is held vertically so that a line drawn between the proximal condyles is directed forwards, the longer axis of the distal end intersects this, making with it an angle of about 60°. This different direction of the ends makes the shaft appear twisted. Relatively to the large size of the articular ends the shaft

looks singularly short and slender. Its cross-section at the middle is roughly trigonal, and the diameters here are 4·5 centims. and 5·5 centims. Owing to the twist of the shaft, that which below is the inner border becomes as it ascends the broad anterior surface above; and the narrow surface at the upper end lying between the outer condyle and the præcnemial crest as it descends becomes towards the distal end the broad antero-external surface.

Of the *fibula* only a small fragment attached to the outer border of the antero-external surface near the lower end now remains.

Foot.—The only parts of this which can with certainty be identified are two metatarsals (Plate 72, fig. 3). In the great size of their joints and shortness and slenderness of the shaft they repeat the most striking features of the femur and tibia. Their distal end has the usual pulley form. The condyles project strongly towards the sole, and the pits for the attachment of the lateral ligaments are large and deep. The proximal end is most expanded vertically. The length of the best preserved metatarsal bone is about 8·5 centims., the breadth of its distal end is 4·5 centims., the longer diameter of its proximal end about 7·5 centims., and the diameter of the middle of the shaft nearly 2 centims.

Respecting the bones considered unguals by Mr. Fox I cannot speak confidently. Their form is broad, depressed, and blunt.

Dermal armour.—Together with the endoskeletal bones a highly developed dermal armour was found. Mr. Fox told me that when he first laid this bare it formed so continuous a mail that his first impression was that he had exposed the carapace of a huge turtle. It measured 3 feet by 3 feet 3 inches, covered the loins, and it was thinner at its middle near the vertebral column than towards its borders. It is now I fear irreparably damaged and beyond reconstruction. Broken up into countless pieces through hasty and incautious removal from the cliffs, these have in 15 years cracked and fallen into numberless smaller fragments; the attempt to rejoin which would be a hopeless undertaking.

Scutes of three forms are readily distinguished: α, simple flat scutes; β, keeled scutes; and γ, spined scutes. Those of the first kind are most numerous. Since none are now entire their shape and dimensions can only be approximately ascertained. They varied greatly in different situations, since some were certainly more than 26 centims. across, whilst the breadth of others did not exceed 1 centim. Their thickness ranges between 3 centims. and 5 centims. Their deep or inner surface is smooth and their outer surface is studded with scattered tubercles. (Plate 71, fig. 3.)

A smaller number of scutes are keeled. The keel, in some, itself unsculptured, rises within a circle of one or more rows of tubercles which are separated from the margin of the scute by a sunken groove, the inner lip of which is thin and projects. (Plate 70, figs. 3, 4, and Plate 72, fig. 4.) It is probable that into this groove fitted the thin edge of the adjoining scute, a mode of articulation giving flexibility with security against dislocation. The deep surface of these scutes is smooth and sinuous. A few

of the keeled scutes have the deep surface angularly excavated. (Plate 71, fig. 7. Plate 73, figs. 1–4.)

The spined scutes are fewer than either of the other two forms. They are all asymmetrical. Their form is rudely triangular, the shorter are obtuse and the longer acute. (Plate 71, figs. 4–6. Plate 76, fig. 1.)

Their base is very stout, its outline is a rhomboid. The blade projects in one of the most perfect, which, however, wants the tip, to 30 centims. beyond the base. The long diameter of the base of this scute is 21 centims. and the shorter 11 centims. One edge of the blade is relatively straight and the other is incurved. A similar difference in the direction of the borders is seen in the smaller scutes of this kind. When a spined scute is placed upon its base on a flat surface the slant of the blade is seen to be considerable; one surface, which in this position is upper, is nearly plane or sinuous transversely, whilst the other surface is transversely convex. The plane or sinuous surface has its distal moiety deeply furrowed by vascular grooves.

With regard to the distribution of the different forms of scutes we have to guide us: α, Mr. Fox's impressions of the armour as he saw it first before it was disturbed and broken up—he says that from its relations to the other bones he thought it covered the loins as a continuous shield; β, inferences drawn from the scutes themselves; γ, the preservation of a few scutes *in situ* in two regions.

The upper surface of the sacrum is still overlaid by a continuous flat scutal covering ornamented with tubercles, which dot it irregularly without definite grouping (Plate 71, fig. 3). I did not detect in it any marks of joints, and am therefore disposed to regard this as forming part of one large plate, which is certainly in its natural position.

The fortunate recovery of the piece sketched in Plate 73, figs. 1–3, shows that an upper row of carinate angularly excavated scutes covered the neural, and a lower row of similar scutes embraced the hæmal spines of the tail. One of these keeled hollowed scutes, which from its large size was probably situated at the root of the tail, is 21 centims. long, 12·5 centims. high, and the angular excavation of its base is 4 centims. deep (Plate 73, fig. 4). Another from near the end of the tail is only 2·5 centims. long by 5 centims. across, and its keel is quite dwarfed (Plate 75, fig. 5). The upper and the lower row of these keeled scutes did not quite meet, but they left a lateral interval filled by a series of smaller flat scutes (Plate 73, fig. 1). Both forms with the diminution of the bulk of the vertebræ underwent a corresponding reduction, and they became towards the end of the tail small button or buckler-like studs, one of which is shown by Plate 75, fig. 6. Thus the whole tail was sheathed in armour.

It has been already mentioned that the spined scutes are asymmetrical. This alone would make it most unlikely that they formed a median dorsal crest. That they were not so placed in the lumbo-sacral region is demonstrated by the preservation of flat scutes there *in situ*. It is not improbable that the spined scutes and the unexcavated carinate scutes encircled with tubercles were grouped in lateral rows.

As no part of the endoskeleton referable to the scapular region and neck was discovered, it cannot be ascertained how far forwards the dorsal shield reached, neither from the material in its present state can any inference be drawn of the presence of ventral armour. The presence of a hæmal series of tail scutes suggests that the belly as well as the back may have been mailed.

The tissue of the scutes is distinctly bony. The vascular canals in the cortex are large and very numerous (Plate 70, fig. 4), suggestive of a stout epidermal covering.

These remains indicate an animal of low stature whose height at the rump probably did not exceed 3 feet. Its strongly marked bones and their large joints speak of its immense muscular power, whilst the shortness of its limbs and the anchylosis of the lumbar vertebræ welding the loins and the sacrum into a long inflexible rod suggest an absence of the lithesome and agile movements of a terrestrial carnivore, and give probability to its having been a slowly moving vegetable feeder.

As regards its zoological position, its dinosaurian marks—the inner femoral trochanter, the lower end of the tibia, and the forked ribs—are so plain that its reference to this Order cannot be doubted. Its place within the Order is also not uncertain. From the Iguanodont family, as represented by its two best known genera *Hypsilophodon* and *Iguanodon*, *Polacanthus* differs widely in the form and proportions of its limb-bones and vertebræ, and by its very highly developed dermal armour, in comparison with which the scutes of *Hypsilophodon* and *Iguanodon* may without inaccuracy be called flimsy. In its stoutly sheathed, crested tail, and its strong body mail *Polacanthus* repeats two striking features of the Liassic *Scelidosaurus*. The scuted caudal vertebra of *Polacanthus* sketched in Plate 73, fig. 1, presents a resemblance to the figure of a corresponding vertebra accompanying Professor R. Owen's "Monograph on Scelidosaurus," which must strike the most superficial observer.

The trunk armour of *Scelidosaurus* is, however, much less developed than that of *Polacanthus*, the spined scutes of the former, so far as these are known from the types preserved in the British Museum, are smaller than those of *Polacanthus*. The resemblance of *Polacanthus* and *Scelidosaurus* is not restricted to their armour, for massive joints are a feature common to both; the differences of shape and proportion of the limb-bones and vertebræ more than suffice, however, to prove their generic distinctness.

Omosaurus armatus, Owen, of oolitic times, had as large dermal spines as *Polacanthus*, but their shape is very different. The dermal spines of the Jurassic *Stegosaurus* figured by Professor O. C. Marsh, in 'American Journal of Science,' vol. xix., March, 1880, plate x., are apparently not smaller than those of *Polacanthus*, but their form differs from these; the limb-bones of *Stegosaurus* are also more slender and the femur wants the inner trochanter. From the lower chalk *Acanthopholis* (Huxley), which has also a somewhat similar mail, *Polacanthus* differs in the greater development of this protective covering and in its very dissimilar vertebræ.

It is to the Wealden *Hylæosaurus* that *Polacanthus* appears most closely related.

The resemblance of their dermal spines is very close, and their tibiæ are remarkably alike. Indeed, I do not know in any public or private collection any bone which the tibia of *Polacanthus* so nearly resembles as the type tibia of *Hylæosaurus* preserved in the national collection and a tibia which a few years since I brought before the Geological Society and provisionally referred to this dinosaur.* It was obtained from Brixton Bay, the locality which yielded these remains of *Polacanthus*. We may not safely compare the metatarsals of this skeleton with those accredited to *Hylæosaurus*, since the type specimen (No. 2556 Brit. Mus. Cat. figured in the Brit. Foss. Rept., Monog. *Hylæosaurus*, plate xi.) is only conjecturally assigned to it, and may have belonged to a very different animal, for the length and slenderness of these metatarsals are not in harmony with the Hylæosaurian tibia so short and with such expanded articular ends. Neither are the type specimens of sacrum and the disconnected vertebræ in the British Museum available, because their reference to *Hylæosaurus* is also conjectural and still requires confirmation. Such comparison, whatever its value may finally prove, however, shows that the sacrum of *Polacanthus* is much more massive and the thoracic vertebræ are longer and less stout than those reputed Hylæosaurian fossils.

Explanation of Plates.

PLATE 70.

Fig. 1. Posterior view of a vertebra from the front of the chest.†

Fig. 2. Oblique lateral view of the same.

Fig. 3. Fragment of a large keeled scute with grooved margin and submarginal rings of tubercles.
k. Beginning keel.

Fig. 4. Sectional view at *x* in fig. 3. (This and fig. 3 are slightly reduced.)

PLATE 71.

(All the figures in this plate are represented rather less than one-half their natural size.)

Fig. 1. Ventral view of sacrum and anchylosed lumbar vertebræ. The numerals 1–5, *s.*, mark the sacral, and the letters *l.l.l.* the lumbar vertebræ.
ng. Nerve-groove.

* 'Quarterly Journal Geological Society,' vol. xxx., 1874, plate xxxi., figs. 1, 2.

† In all the representations of vertebræ. *c.* Centrum. *ns.* Neural spinous process. *prs.* Præzygapophysis. *psz.* Postzygapophysis. *d.* Diapophysis. *p.* Parapophysis. *c.c.* Capitulum costæ. *r.* Rib-shaft.

Fig. 2. Cross sectional outline at fracture through the third sacral vertebra.
Fig. 3. Dorsal view of fragment of the large scutal shield resting on the fourth and fifth sacral vertebræ.
Fig. 4. Lateral view of a large dermal spine.
Fig. 5. Basal view of the same.
Fig. 6. Edge view of the same.
Fig. 7. Keeled scute with angularly excavated base.
The border *x* in this and in fig. 4 correspond.

PLATE 72.

Fig. 1. Oblique view of a caudal vertebra.
Fig. 2. Anterior view of the centrum of the same.
Fig. 3. Oblique lateral view of two metatarsal bones.
Fig. 4. Fragment of a large keeled scute with grooved border and submarginal ring of tubercles.
k. Keel.
g. Groove.

PLATE 73.

Fig. 1. Lateral view of a fragment of the tail, sheathed by hæmal and neural keeled scutes, between which are the remains of a lateral series of small peltate scute tubercles. The vertebral centra, *c.c'.*, are overlaid by bundles of ossified tendons, *t.*
Fig. 2. Sectional view of the fractured surface at *c'*.
c. Crushed centrum.
k.k. Hæmal and neural scutes.
Fig. 3. Foreshortened view of scute at *x*. *b.* marks the same border in this and in fig. 1.
Fig. 4. Lateral view of a large keeled scute with angularly excavated base.

PLATE 74.

Fig. 1. Front view of the right femur (nearly $\frac{2}{1}$).
Fig. 2. Back view of same (nearly $\frac{2}{1}$). (This is represented upside down.)
cap. Caput femoris.
tr.m. Trochanter major.
tr.i. Inner trochanter.

PLATE 75.

Fig. 1. Front view of the left tibia (nearly $\frac{2}{1}$).

Fig. 2. Back view of the same (nearly $\frac{2}{1}$).
cd. Condyles.
pr.c. Præcnemial crest.
f. Fragment of fibula.

Fig. 3. Side view of a caudal vertebra, where the transverse process has disappeared, and the spinous process has become dwarfed.

Fig. 4. View of posterior surface of fig. 3.

Fig. 5. Small keeled scute upon a vertebra from near the end of the tail.

Fig. 6. Small buckler-like scute from near end of tail.

PLATE 76.

Fig. 1. Lateral view of a large dermal spine (slightly reduced).

Fig. 2. Fragment of a rib.

Fig. 1.

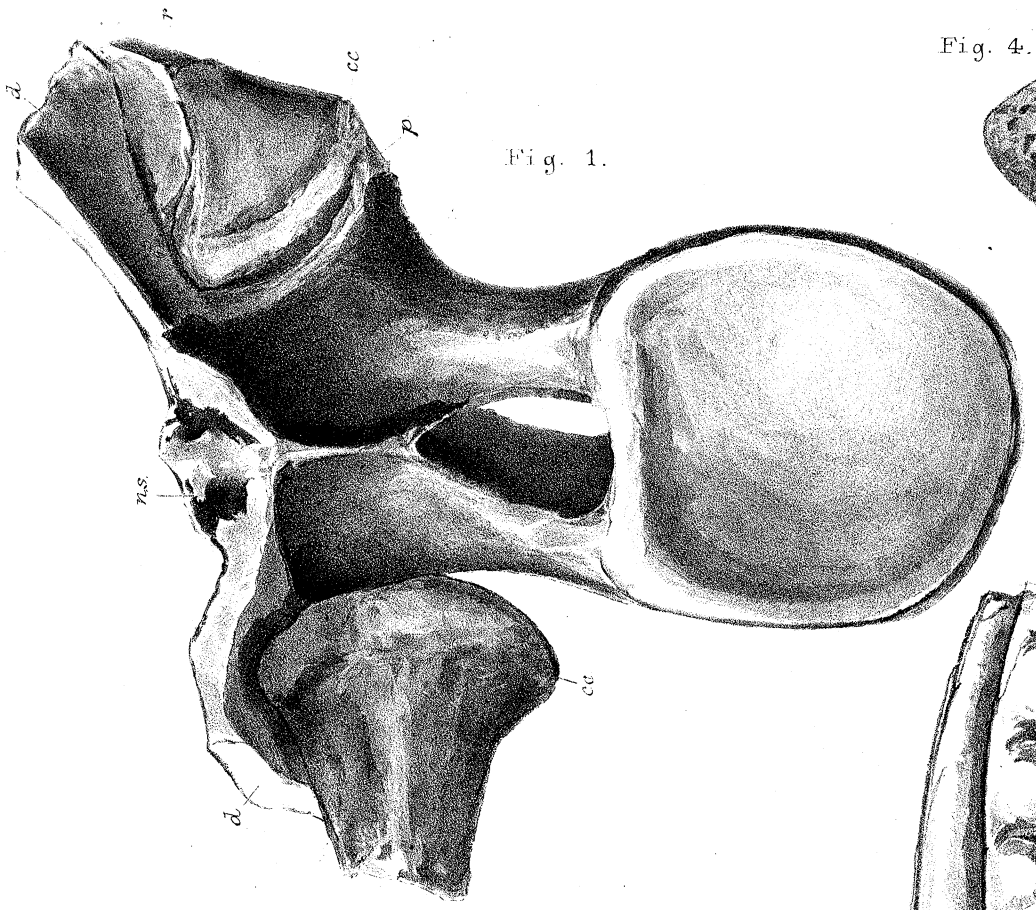
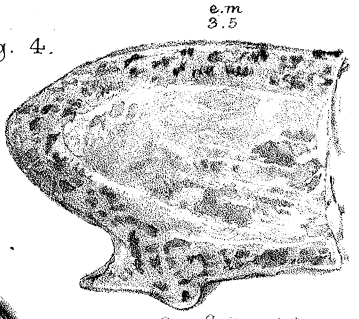
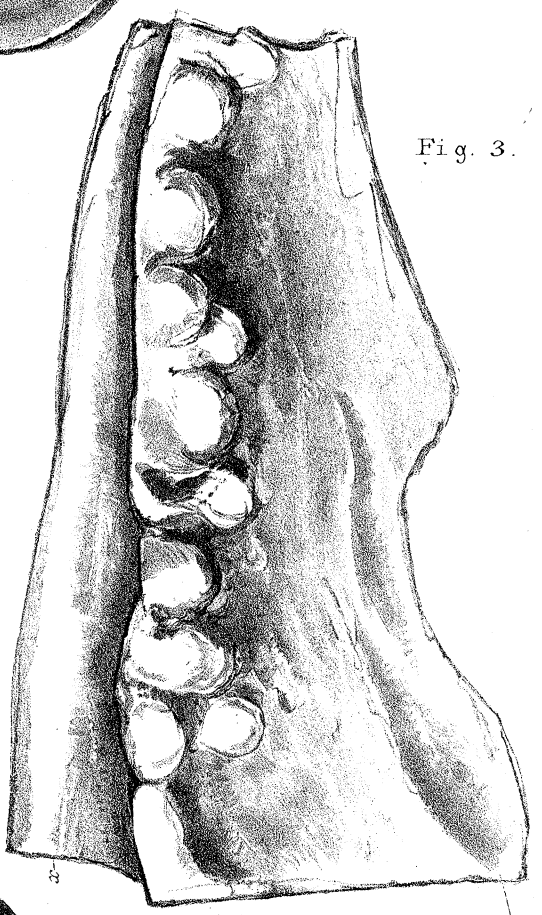


Fig. 4.



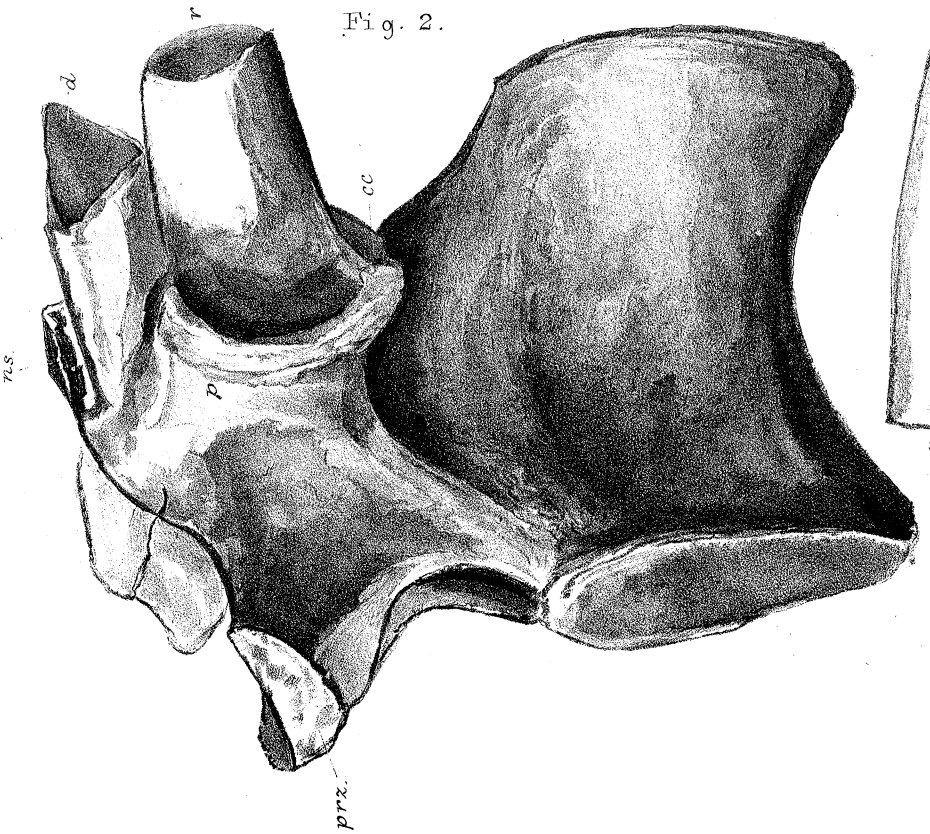
Cross Section at d.
Slightly reduced.

Fig. 3.



Slightly reduced. Beginning Keel.

Fig. 2.



J.W. Hulke del.
W. H. Wesley lith.

West Newman & Co imp.

Fig. 3.

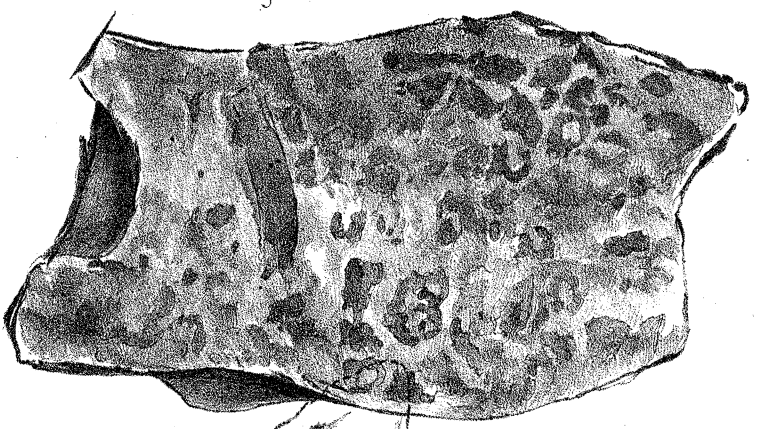


Fig. 1.

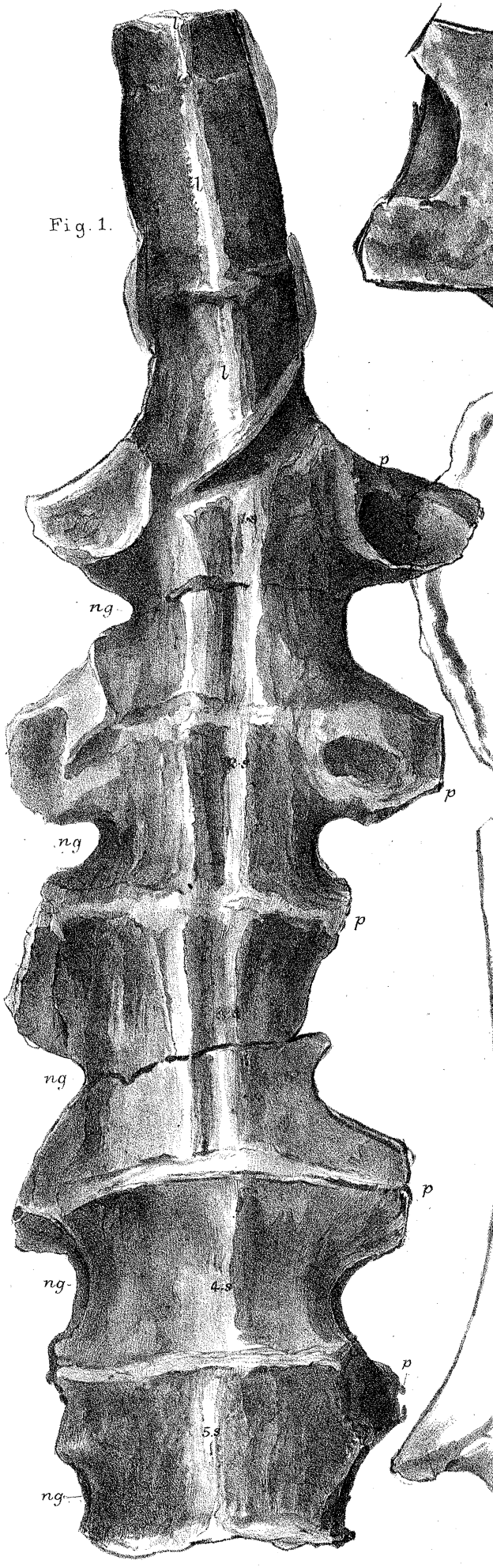


Fig. 5.

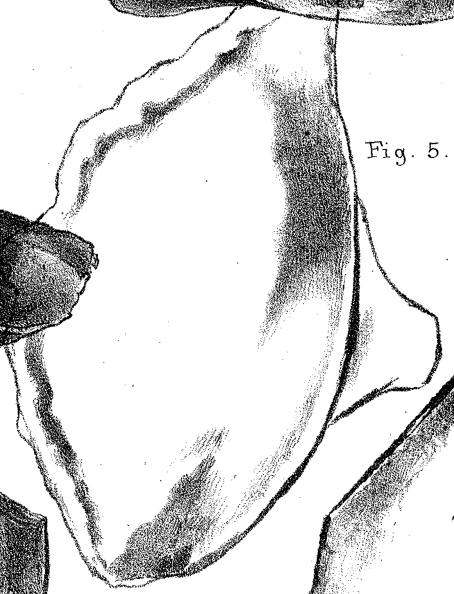


Fig. 4.

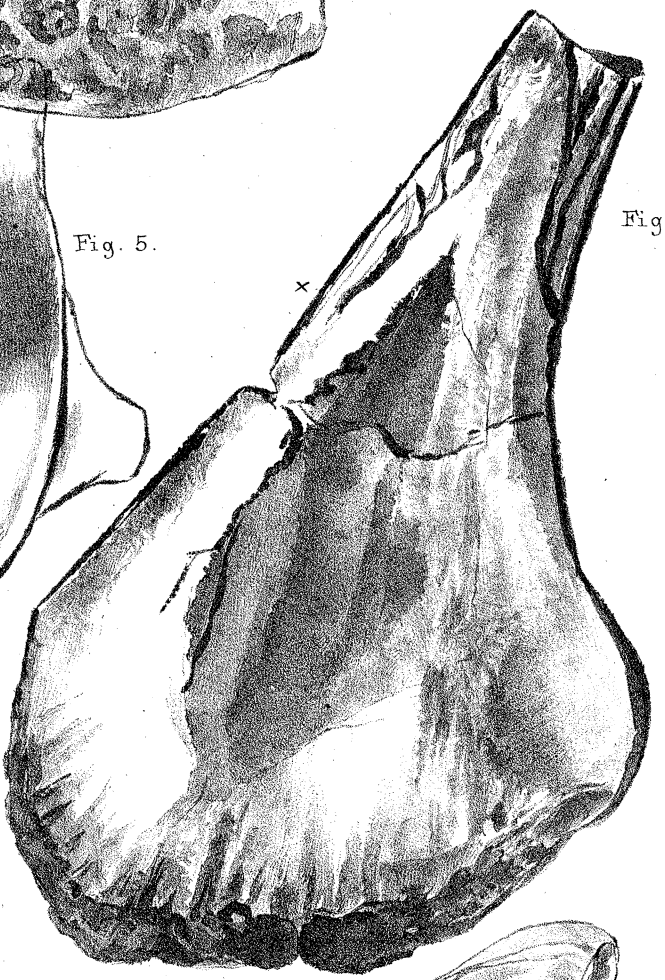


Fig. 6.

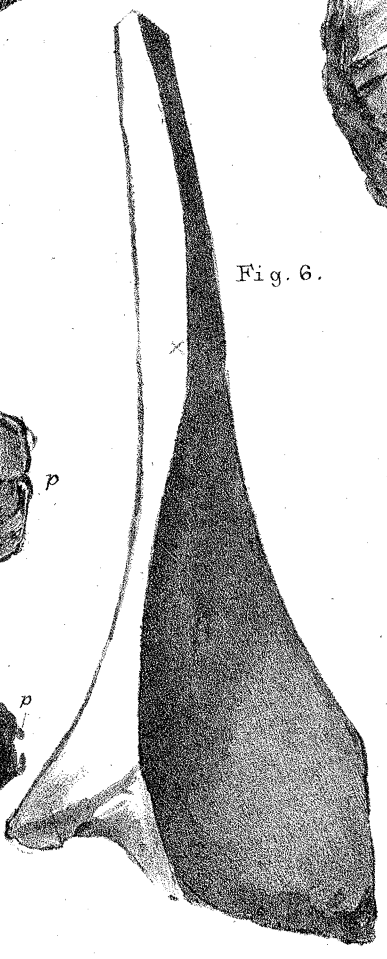


Fig. 7.

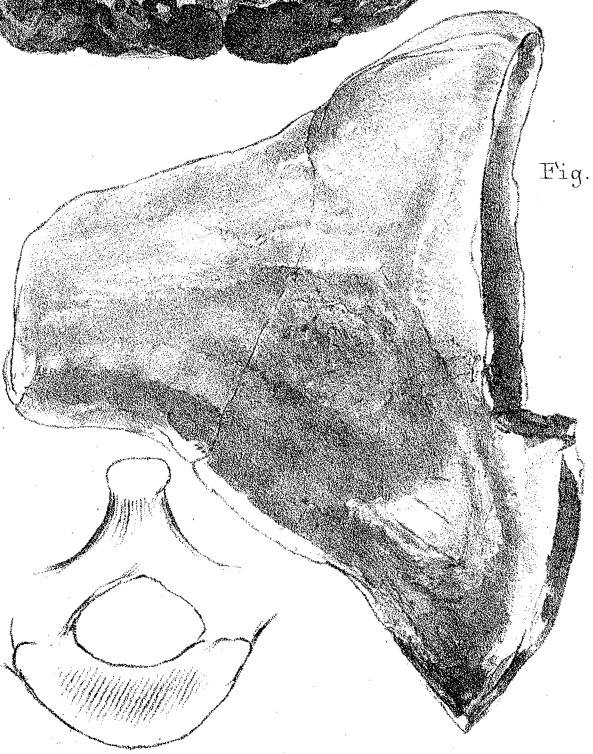


Fig. 2.

Fig. 1.

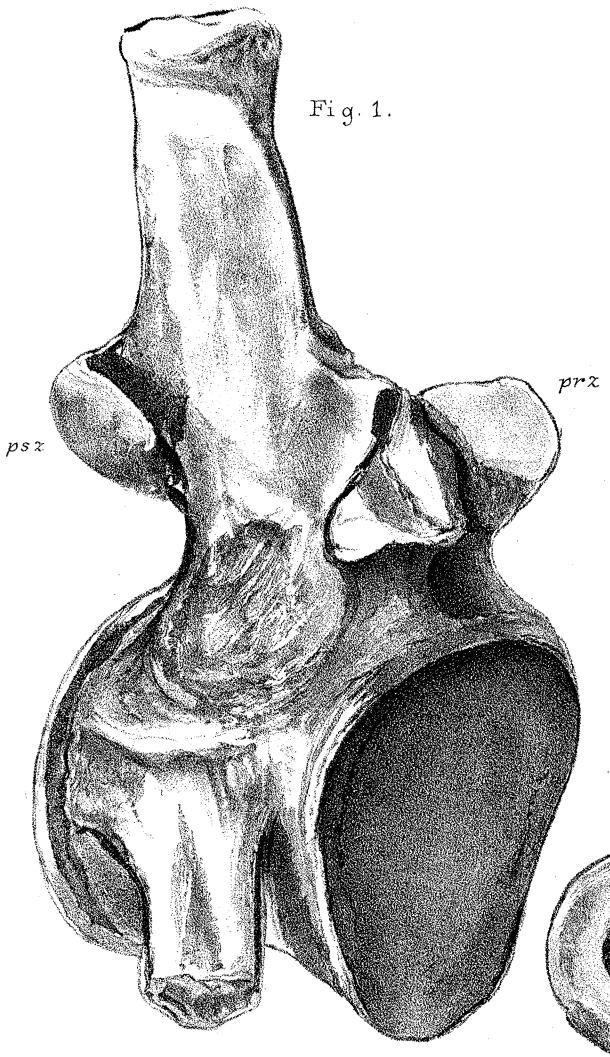


Fig. 2.

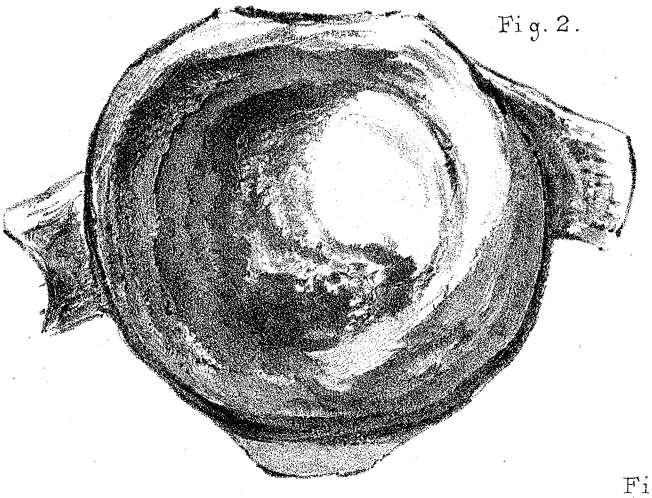
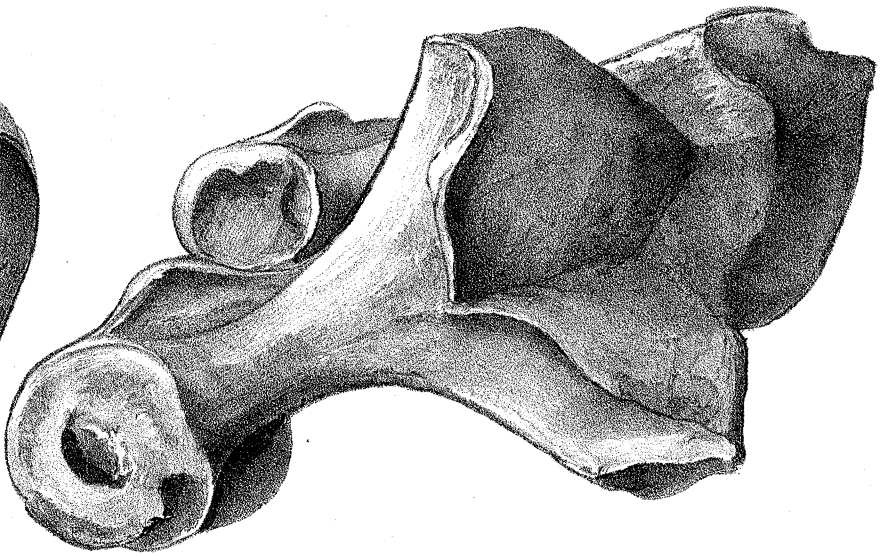


Fig. 3.



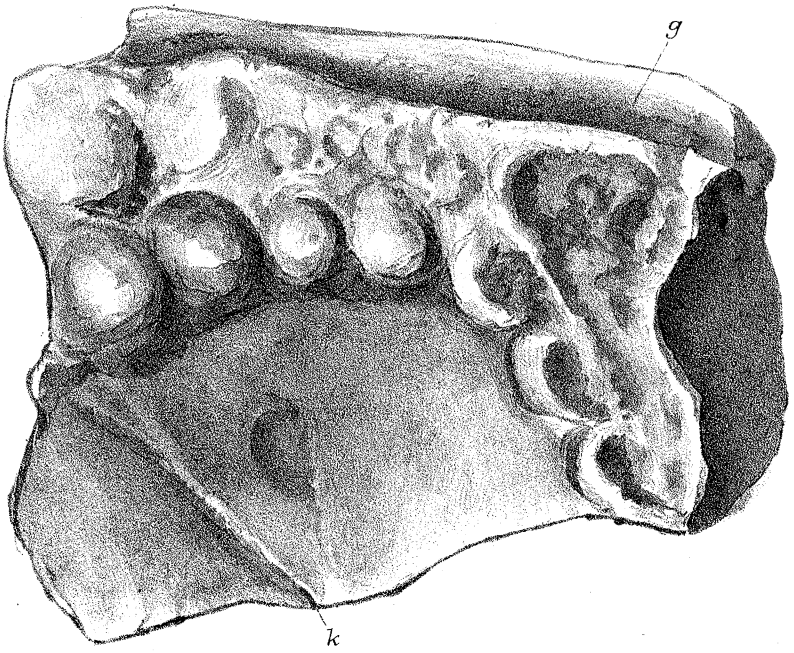


Fig. 4.

J.W. Hulke del.
W.H. Wesley lith.

West Newman & Co imp.

Fig. 4.

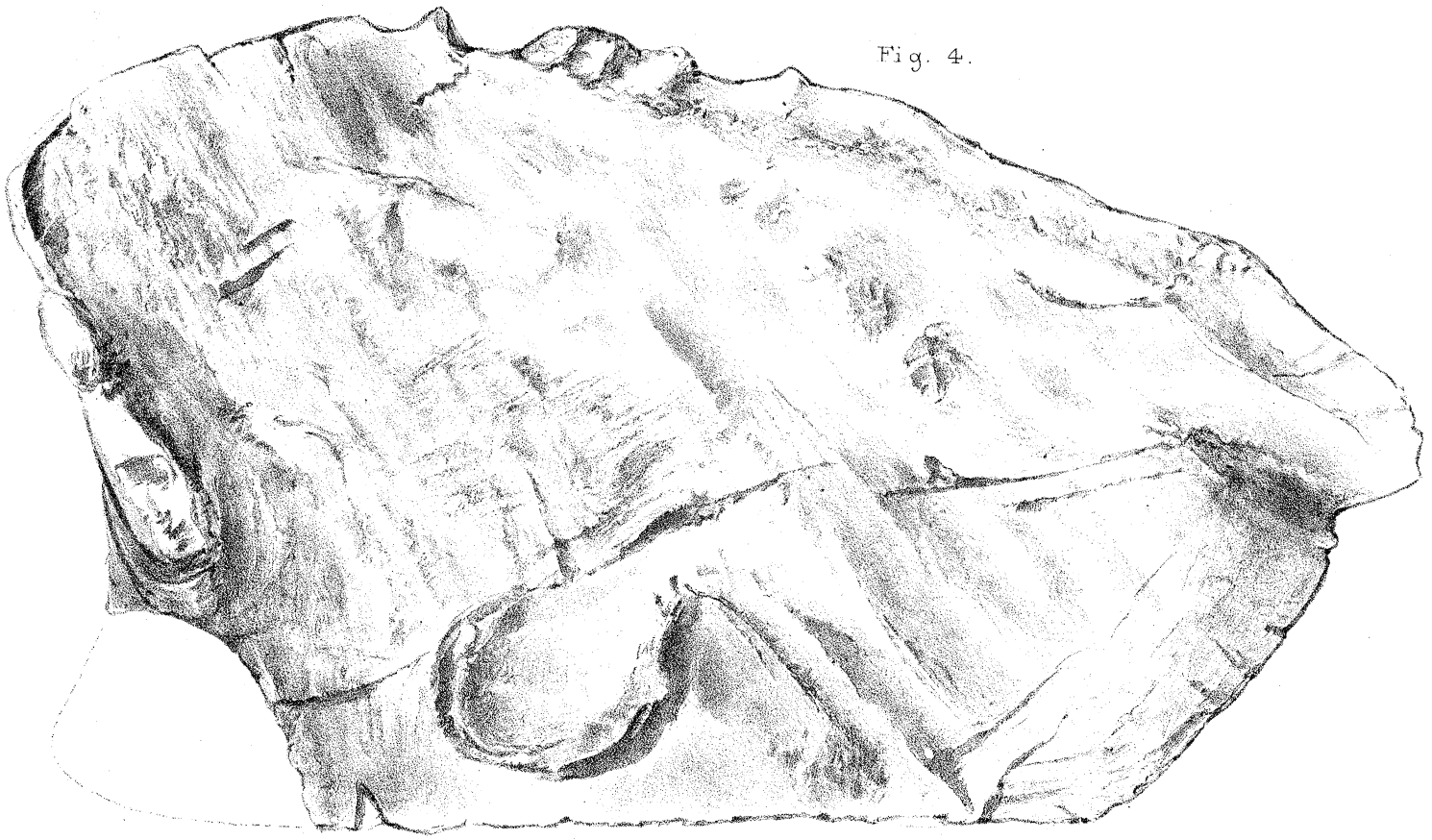


Fig. 3.

Fig. 1.

Fig. 2.

J.W.Hulke del.
W.H.Wesley lith.

West Newman & Co imp.

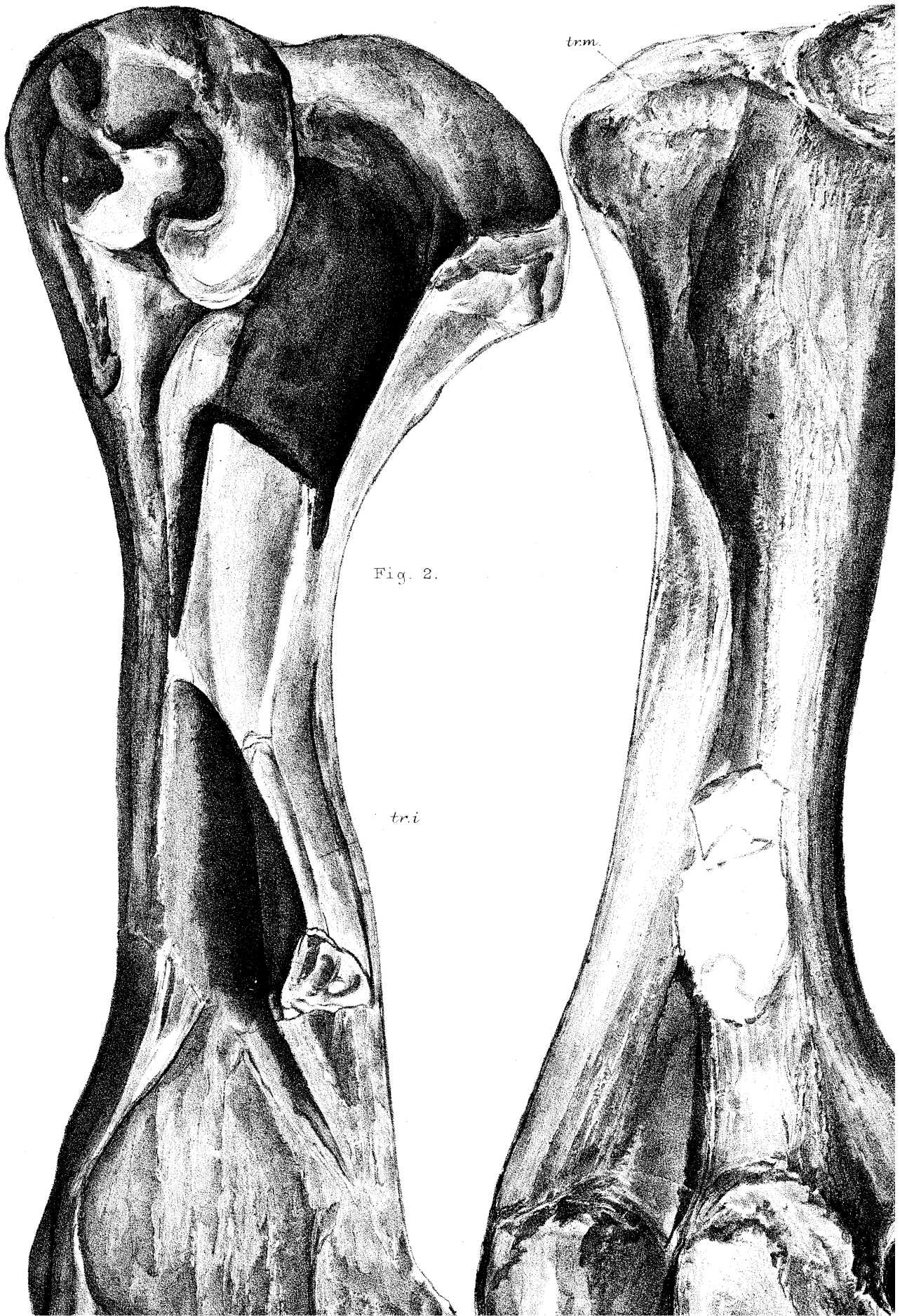


Fig. 2.

is. 1881. *Plate* 74.

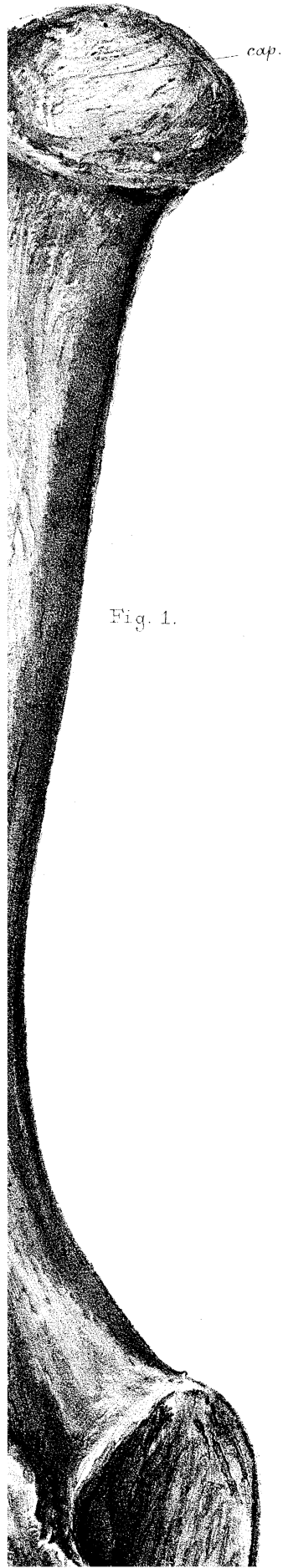
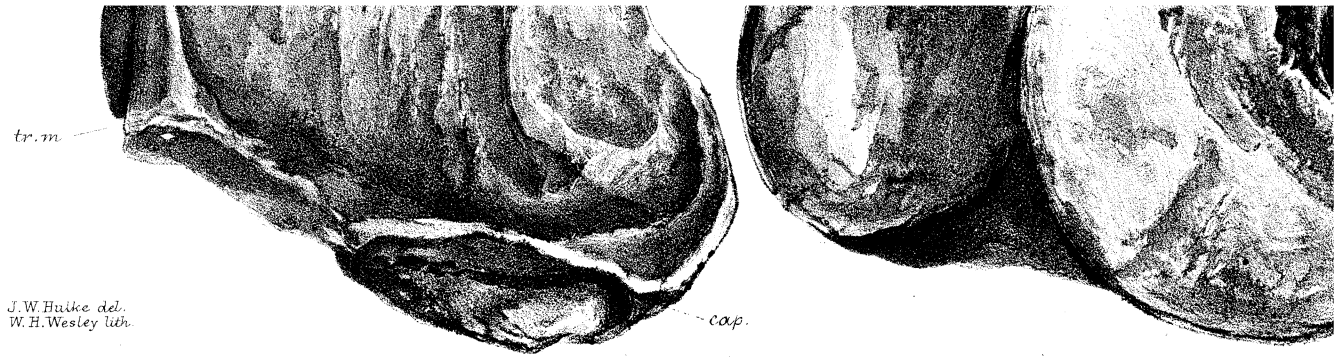


Fig. 1.



J.W.Hulke del.
W.H.Wesley lith.

West Newman & Co imp.

Fig. 2.

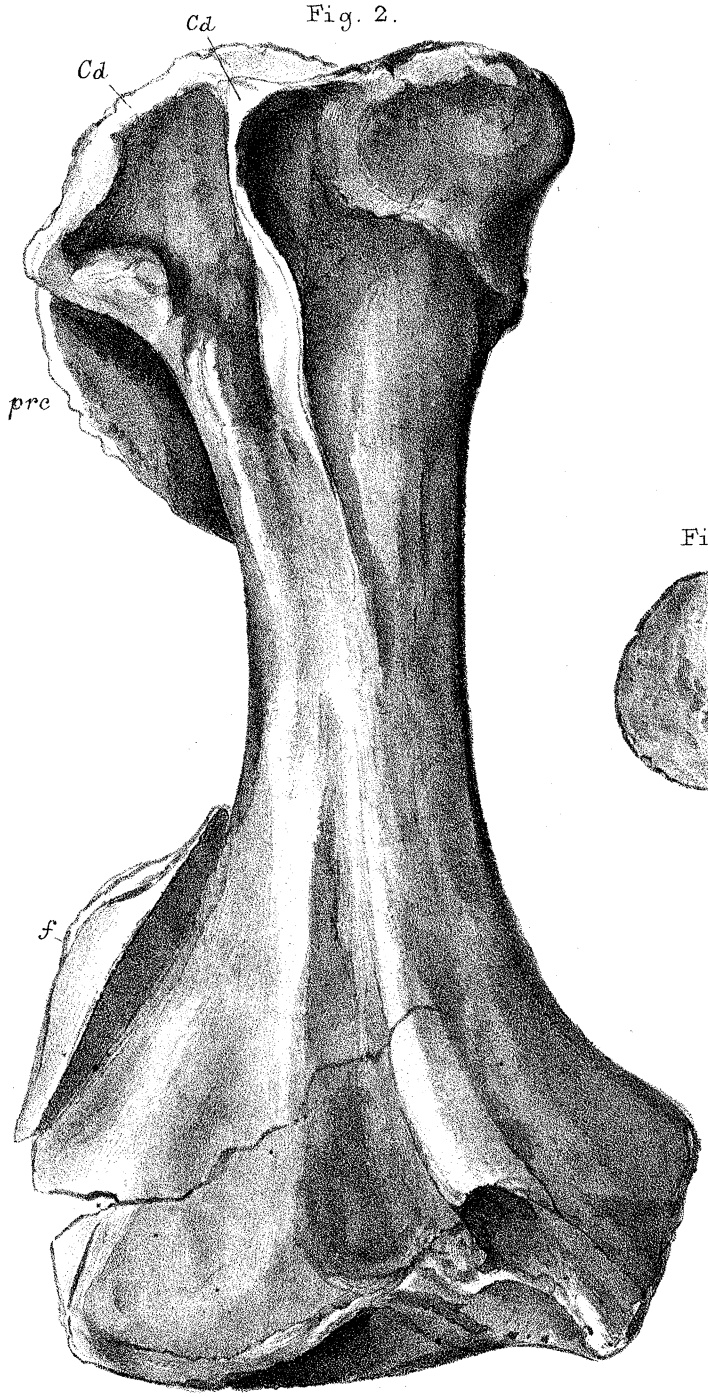


Fig. 1.

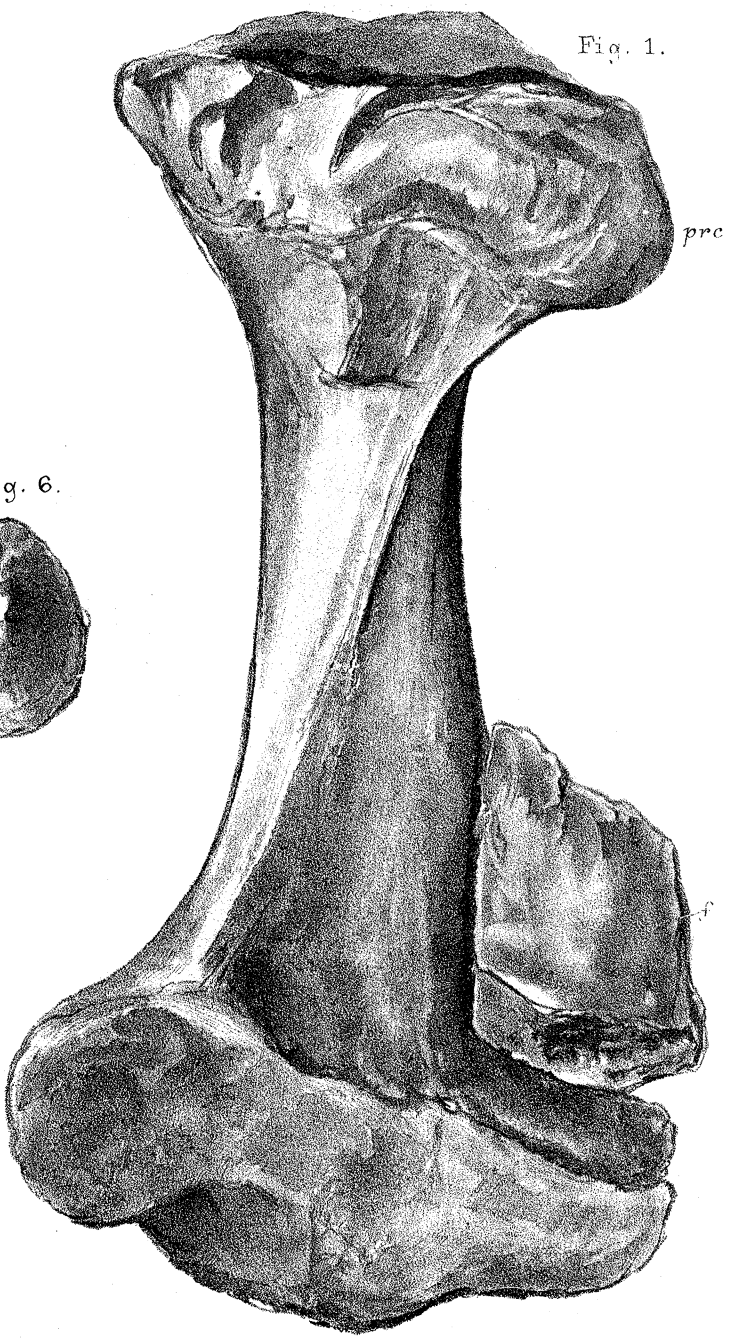


Fig. 6.

Fig. 4.

Fig. 3.

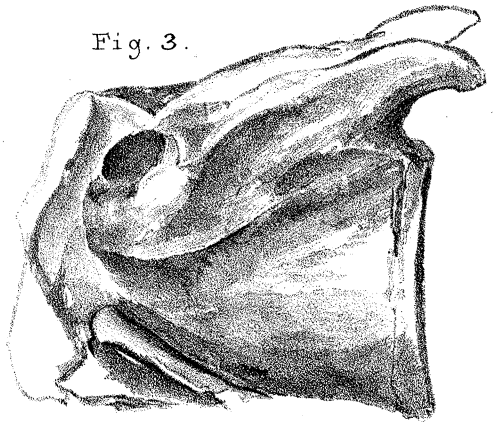
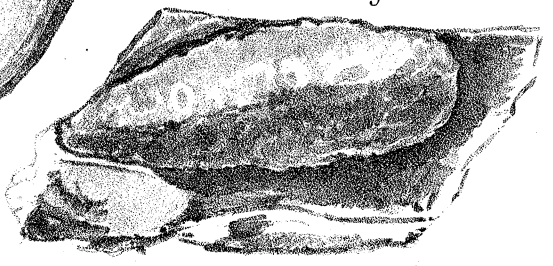


Fig. 5.



J.W. Hulke del.
W.H. Wesley lith.

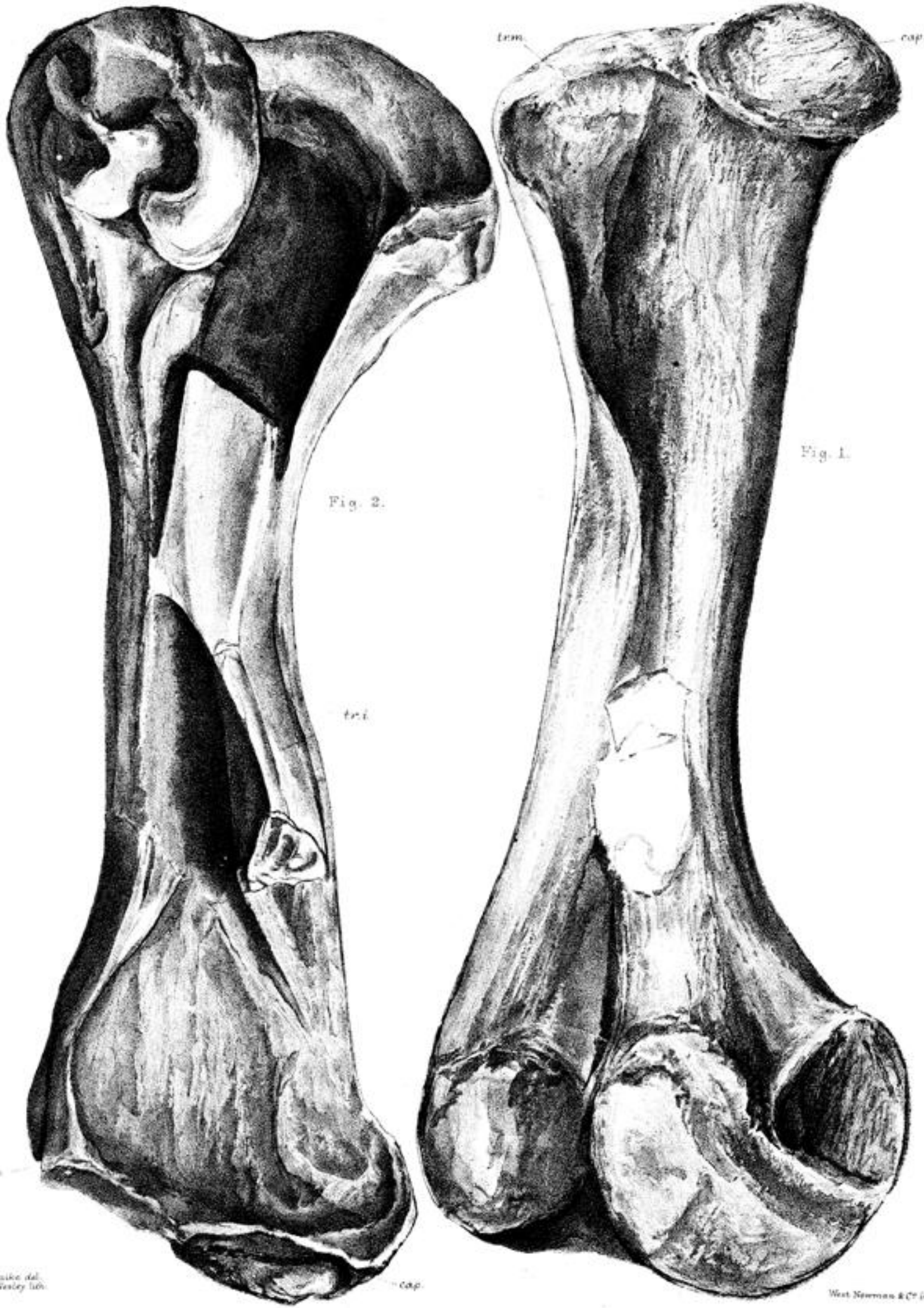
West Newman & Co. imp.

Fig. 2.

Fig. 1.

J.W. Hulke del.
W.H. Wesley lith.

West Newman & C° imp.



J. W. Hulke del.
W. H. Wesley lith.

West, Newman & Co. imp.